NATURE

No. 3795 SATURDAY, JULY 25, 1942 Vol. 150

CONTENTS

	Page
Universities in War-time	97
The Anatomy of Freedom. By Prof. A. D. Ritchie	100
The Laboratory Mouse. By Dr. Hans Grüneberg	101
New Cytological Technique. By Dr. Irene Manton	102
Precolombian Haiti. By G. H. S. Bushnell	103
The Values of Science to Humanity. By Prof. A. G. Tansley, F.R.S.	104
Portable Mass Spectrometer. By John A. Hipple, jun.	111
Care of Works of Art in War-time. By F. Ian G. Rawlins	112
Obituaries :	
Sir Daniel Hall, K.C.B., F.R.S. By Sir John Russell, F.R.S.	114
Prof. D. la Cour. By Prof. S. Chapman, F.R.S.	115
News and Views	116
Letters to the Editors:	
Number of Primes and Probability Considerations.—Prof. W. H. Furry ; The Right Hon. Lord Cherwell, F.R.S.	120
Relationships of some Primitive Tetrapods.—Dr. T. S. Westoll	121
Narcotic for Marine Invertebrates.—Isabel C. Ledingham and G. P. Wells	121
Enamel Organ of the Rat's Incisor Tooth in Vitamin E Deficiency.—Prof. J. T. Irving	122
Selective Excitation of Spectra by the High-Frequency Discharge.—Prof. R. K. Asundi and Nand Lal Singh	123
The Problem of the Autonomy of Life.—Prof. Reginald O. Kapp; Prof. F. G. Donnan, C.B.E., F.R.S.	123
General and Social Biology.—Sir James Barrett, K.B.E., C.B., C.M.G.	124
Higher Algebra.—F. G. W. Brown	124
Pyrethrum Sprays.—Dr. E. A. Parkin	124
Mineral and Vitamin Requirements and the War-time Dietary. By Prof. R. A. Peters, F.R.S.	125
Amino Acid Analysis and the Structure of Proteins. By Prof. A. C. Chibnall, F.R.S.	127
Timber-seasoning Kilns	127

Editorial and Publishing Offices
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2
Telephone Number : Whitehall 8831
Telegrams : Phusis Lesquare London

Advertisements should be addressed to
T. G. Scott & Son, Ltd., Three Gables, London Road, Merstham, Surrey
Telephone: Merstham 316

The annual subscription rate is £4 10 0, payable in advance, Inland or Abroad

All rights reserved.

Registered as a Newspaper at the General Post Office

UNIVERSITIES IN WAR-TIME

THE extent to which the universities of Great Britain are addressing themselves to the war effort is well indicated in an admirable series of articles which has appeared in *Britain To-day*, and also by a survey of the "University of London in War-Time, September 1939–March 1942", recently circulated in the Convocation of the University. Their part in reconstruction is no less vital. Both aspects of university war-time activity are reflected in two articles, which have appeared in a recent issue of *Science* (**95**, 369–72, 372–73 ; 1942), by Dr. Arthur Cutts Willard and Prof. A. J. Carlson respectively. Dr. Willard's address, "The University and the War", given at the Washington award dinner of the Western Society of Engineers, describes the ways in which the courses of the University of Illinois have been modified to meet professional demands for various services and its contribution to the war programme of the United States through the research activities of its scientific staff. The mere list of activities cited by Dr. Willard indicates that the University of Illinois is addressing itself to the immediate practical tasks of education, training and research, with vision and understanding. The contribution to morale of the Extension of Service in Agriculture and Home Economics, the trained specialists of which present to the people the results of scientific research carried out by the Agricultural Experiment Station, often in co-operation with the U.S. Department of Agriculture, is noteworthy, and the Engineering Science and Management Defense Training Programme is most impressive. Adult education, education in the armed forces and the encouragement of reading on the understanding of America, its aims, the War and the peace to follow are all represented.

Whereas the material contribution of the universities, of which London and Illinois are only examples, is important, the moral and spiritual contributions are even more important, and it is to this particularly that Prof. A. J. Carlson, of the University of Chicago, directs attention in his paper "The University and the Present Crisis". Emphasizing the particular dangers inherent to a university in time of war—which are involved in the very antithesis of education and war—he warns us of the importance of a re-examination of the relation of education and democracy before we attempt to modify educational institutions or systems in a period of hysteria and fear. There should be no relaxation in our standards of education, university or other. A period of war is not the best time for inaugurating basic educational reconstruction, though it is well to give timely consideration to the subject ; and a democracy should be specially on its guard against the dangers to education and to fundamental research which are always present in a war effort of the magnitude of that at present required.

From these comparatively negative obligations, Prof. Carlson turns to the positive obligations of the university at the present time. Among these he places foremost a tightening of the intellectual belt,

a greater attention to duty for teachers and students. Waste of time must be rigorously eliminated, and both teachers and taught must recognize their responsibility for seeing that the golden hours are used to the full. The practical duties of placing university facilities at the disposal of the Government for training men in the special services of the armed forces, and for aiding in the solution of scientific and other problems forced on us by the War are put first, the training of the full quota required each year of medical men, physicists, chemists and engineers comes next, while finally Prof. Carlson stresses the importance of free minds, informed by principles derived from human experience through the ages, and open, no matter what waves of change beat upon them.

The duty and responsibility for aiding in the development and maturing of such creative and open minds lie mainly on the university, both in peace or in war. The universities are among the ultimate safeguards of freedom of thought, and to them we must look for the constructive criticism and imaginative insight essential in the elaboration of any sure plans for reconstruction when victory is won. The intellectual activities of the university, as President Hutchins writes, are the symbol of everything we have to defend, and the best service the university can render in the defence of the United Nations is to see to it that these activities are maintained in full force and vigour. Only the universities can carry the incredibly heavy burden of formulating, clarifying and vitalizing the ideas which should animate mankind; they must carry that burden, even in total war, if civilization is to be saved.

It is encouraging that the exceptional stimulus that the present struggle is undoubtedly giving to scientific thought is not leading the universities to overlook the great resurgence of social, economic, political, industrial and educational leadership which is required nationally and regionally. Possibly our Russian allies are prone to over-emphasize the material side of the university's contribution, as an article by Dr. P. Kapitza "Science and War" in *Science* (95, 396; 1942) suggests; but Dr. Kapitza also points out that the strain and tension due to war are exposing the weak spots in our economy, technique and organization, showing the points where the State must first be assisted, and clearly formulating the demands which society makes on science. In his speech in the House of Commons on June 16 on the estimates for his Department, Mr. Butler, president of the Board of Education, referred to the contribution to the war effort in the steady flow of qualified recruits for the specialized services, but it was clear that the importance of something more than academic qualifications for leadership was in his mind.

This was shown, for example, in the appointment of a committee, with Dr. McNair, vice-chancellor of the University of Liverpool as chairman, to investigate the recruitment of teachers from other academic services, as well as the question of the supply of teachers and of youth leaders. This and other steps already taken, such as the short courses for teachers in the history and current affairs of the United States and of the U.S.S.R., initiated in close co-operation with the American and Russian Ambassadors, and the establishment of a body under the chairmanship of Lord Fleming to work out a plan under which the facilities of a boarding-school education may be extended to those who desire to profit by them, irrespective of their means, while but indirectly connected with the universities, will facilitate the fulfilment of their task of supplying the nation with the trained leaders it requires.

The quality of the leaders which a university provides does not indeed depend solely upon the university itself. It depends partly at least upon the quality of the students entering on its courses, and therefore to some extent on educational systems of the schools. It is well to find, therefore, a new outlook on education reflected in the House of Commons debate, and such promising plans outlined in Mr. Butler's speech, though it should be remembered that much of the information required as a basis for decision has already been set before the Government by the Consultative Committee of the Board of Education with the aid of school inspectors. What is, in fact, required of the Government here is a definite plan for education, from the primary school to the university, upon which ultimate decision and action can be taken.

The real problem in a democratic society, in education as elsewhere, is to secure the full use of the nation's talents. The McNair Committee may be expected to advance proposals regarding the supply of teachers which will redress the lack of missionary zeal and first-rate competence; but this is only one direction in which the task is to open the door to men and women who can best serve by their boldness and ability, to give them opportunity in their public work and in their private lives to execute plans of action and to take responsibility. In the Civil Service adventurous spirits are lacking; in industry, vision and courage; in politics, honest, able men are scarce; and pride, enthusiasm and capacity are too often absent from the humblest to the highest spheres of work.

It is the function of the nation's schools and universities to provide the channels along which these men and women will pass. To make the schools themselves open to all equally, and at once uniformly well endowed in equipment and personnel and widely diverse in their freedom to develop, are essential steps to this end. Also it is essential that, simultaneously through the universities and by adult education, the nation should be brought to a new appreciation of the moral values upon which democracy is built and without which we look in vain for real leadership of youth or of any age.

If the schools and universities are to supply this creative leadership which is our first need, both alike must concern themselves with the preservation of moral standards and spiritual values. Too long have we allowed, as Lord Elton points out in his stimulating book "Saint George or the Dragon", the military virtues of loyalty, courage, endurance and discipline, upon which our very existence now

depends, to be despised, ignoring the fact that they are the very basis of civilization itself; and punctuality, regularity and industry to be sneered at as slave values. Yet without these last even creative genius will never see the fruition of its gifts to man; and the first, though not the only Christian virtues, lie so close to the core of Christianity that we can scarcely wonder that twenty years campaign against them has led to a weakening in the hold of Christianity itself. Indeed, they can be reduced, as Lord Elton notes, to a single quality, unselfishness, and if there is one defect more than any other responsible for our unpreparedness for the present War, for the defects of the present social order, for the softness and love of ease and pleasure which may have led our foes to misjudge us but also earned their just scorn, it is the directly opposed vice of selfishness.

We may well be grateful to Lord Elton for his penetrating exposure of the shallow and misguided intellectualism which for twenty years has been so rampant against the virtues we need alike to win the War and to build the peace. Unless that lesson is learnt aright, there will indeed be no place to build. Civilization is self-discipline, and its advance is measured by man's gradual mastery of his more savage instincts. That much at least Nazism has revealed to us, and having once overthrown that menace it would be folly indeed to throw aside the moral values which have brought us to victory without making sure that we have found new and enduring values adequate to the spiritual as well as material tasks which lie ahead.

The extent to which the moral and intellectual foundations of civilization have been shaken is nowhere better revealed than in our lost capacity for moral indignation. The evil could, however, scarcely have gone so far had there not been a widespread indifference to the basic importance of character. From this the War has happily aroused us, and it has already been demonstrated that the nation possesses formidable reserves of courage, loyalty, fortitude and endurance, and that there is little lack of those willing to accept responsibility. It must, however, be the first concern of any kind of educational system to see that the emphasis on the training of character is never again omitted, from the university downwards. There must be no further betrayal, and the extent to which the conception of service is replacing that of private profit in the realm of industry and commerce must be reflected throughout that of education. That idea lies at the heart of the youth movement, but unless it is fortified continually by the teaching and example of the schools, the movement will never fulfil its promise.

In his stimulating chapter "Not Examinees, but Men", Lord Elton is writing primarily with the schools in mind, but what he says of them with regard to training in citizenship and the more effective choice of leaders is equally true of the university. The system of examination in book learning alone can no longer be retained. Means must be found of testing other qualifications for leadership besides the capacity to absorb and reproduce knowledge. Courage, common sense, originality of mind and sound physique —these also must be taken into account; and we should make sure that the educational ladder of the future is one to be climbed by boys who show signs of initiative and character as well as intelligence.

In the gearing of intelligence to character and experience, the retention of national service after the War may well play an important part. Conscription, whether in the fighting services or in the factories or on the land, might do much to toughen the physique, socialize the instincts and enrich the later learning in school or university. Moreover, by emphasizing the idea of obligations and services to the State from every citizen as the condition upon which its protection and privileges are enjoyed, it might do much to fortify the youth of the nation against the softness and heresies which the propaganda attacked by Lord Elton broadcast so disastrously between the wars.

The universities have a part to play here through the recognition of social studies. By a fuller and deeper appreciation of the importance of man as a vital entity in the structure of a dynamic civilization, they can lay the foundation for, or round off, as the case may be, the experience which a short period of national service can give.

No excellence in the material contribution of the universities in peace or in war can atone for any shortcomings in moral or spiritual leadership. It is not enough to recognize the shallowness and ineffectiveness of much of the intellectualism and scepticism of the last twenty-five years. Without idealism, without conviction, without a sense of the positive values of life, and a vision of those enduring spiritual verities of mankind, now imperilled, but by which alone man has made his slow advance out of the darkness and chaos of barbarism, there can be neither the moral passion which will overthrow the aggressor nor the balanced view of life which will enable a nobler and wiser civilization to emerge from the present turmoil. Man needs the inspiration of a living faith and an adequate working philosophy if he is to bring to the tasks that now confront us the serenity and the conviction that will bring them to success, and overthrow the forces making for social disintegration, whether in society, in industry or in international affairs.

The late Prof. J. L. Stocks said truly in his essay on the need for a social philosophy that our generation is not being given the tools necessary for a sound critical judgment in social affairs. Philosophy, he says, alone has the power to give them those tools. When men do not know the faith by which they live, they will be apt inadvertently to betray it. The universities are no longer academies of religion, though for centuries it was one of their main tasks to train the leaders of the Church. To them men may fairly look, not for the light of truth alone but also for the compelling force of moral conviction, for the enthusiasm which has a place in all genius and all creative work, and for the vision and wisdom by which men may steady their course and walk surely in this anxious, crumbling world.

The universities fail of their full purpose unless

they give to their alumni in some measure the power to see life steadily and to see it whole, and the capacity to re-discover and re-create for each fresh generation truth in all its many facets which, as Dr. R. R. Marett reminds us, can never afford to stand still. With courage, loyalty, discipline and endurance, a civilization may be strong to defend itself, but without also culture and religion it is unworthy and indeed unable to survive.

Here then is the point at which the universities must face anew the interpretation of religious experience and of the spiritual heritage of mankind. Their responsibility to-day for imparting to all their students and scholars some sense of the scientific outlook and spirit, with its untiring passion for truth, the ceaseless testing and sifting of the accumulated knowledge of mankind as part of the discipline which equips men and women alike for life and leadership in this modern world, is admitted. There must now be recognized also their responsibility for instilling as a counterpart to legitimate scientific scepticism a respect for the accumulated wisdom of mankind, and a training in cultural and ethical values which will lead to the formation of sound judgment.

To leave the young, in the sphere of wisdom, to re-discover painfully for themselves the moral and spiritual truths which the accumulated experience of past generations has accepted as making for the good life in the individual and in the State is neither science nor sense. In the sphere of knowledge, the scientific worker does not hesitate in practice to accept the conclusions of the past, or to stand upon the shoulders of his predecessors. Both in knowledge and in the realm of wisdom, to reject all the observations and experience of the past and to insist on verifying afresh every single fact or technique leads at once to chaos and deadlock, not to progress.

It is this task of cherishing the rich moral and spiritual heritage of mankind and stimulating the creative thought which will lead to the discovery and formulation afresh of a faith and a philosophy adequate to meet the challenge of to-day that is the supreme responsibility of the universities. They, as none other, can build up the aristocracy of ability and integrity which Zinsser insisted is essential to maintain a democracy and protect it from deterioration and eventual chaos. If science and religion are to found a fellowship which will lead men forward, facing change in the spirit of science, trending upward in the way which religion alone in the elements of human experience, as Whitehead points out, has consistently done, the universities will assuredly prove a decisive factor. Only as they play their full part can those bright hopes of the youth movement or the vision of service, of sacrifice and adventure dawning anew on the minds of men and women in so many scattered walks of life, find their fulfilment in action and in a fellowship strong and serene enough never to be turned again by selfishness or love of ease from the task of building a nobler world order and adding, in response to the call of prophetic statesmanship, their own contribution to their heritage of culture, learning and religious experience.

THE ANATOMY OF FREEDOM

Freedom: its Meaning

By Benedetto Croce, Charles A. Beard, Jacques Maritain, Bertrand Russell, Gaetano Salvemini, Vilhjalmur Stefansson, Henry A. Wallace, Henri Bergson, Alfred North Whitehead, Thomas Mann, Felix Bernstein, Harold J. Laski, John Macmurray, Albert Einstein, J. B. S. Haldane, Lancelot Hogben, Frank Kingdon, Franz Boas, John Dewey. Planned and edited by Ruth Nanda Anshen. Pp. vii+335. (London: George Allen and Unwin, Ltd., 1942.) 16s. net.

A VARIED assortment of essays make up this book. Though it is certainly useful to have these different points of view and different subjects brought together for comparison, the method has disadvantages. The essays are arranged in alphabetical order of the authors' names, an arrangement more convenient for the editor than the reader. Three of the essays (those by Bergson and Profs. J. Dewey and A. N. Whitehead) are chapters taken from published books, and it is possible that their original context suited them better. There is a serious gap in the ground covered: namely, no more than incidental references to the legal aspect of freedom. Prof. H. J. Laski could have done this very well, but he has preferred to discuss the problem of nationalism as an obstacle to freedom. If only each writer, before finally committing himself, could have read a preliminary draft of the other contributions, it would have been an improvement. For example, it would have saved Dr. V. Stefansson 'flogging a dead horse' if he had read the explanation by his fellow anthropologist, Prof. Boas, that primitive man lacks the concept of freedom. Unfortunately, this last suggestion is a counsel of perfection. Only a superhuman editor could cope with such conditions.

Despite these defects, the editor's claim to have reached a synthesis is more nearly realized than one would have thought possible before reading the book. Present-day facts speak too clearly to be ignored. We can all see, to quote Benedetto Croce, "the barrenness in terms of thought, science, art, civic virtues, human relations, that systems based on violence—or on what amounts to the same thing, on authority—commonly show. Everything sound and productive that still survives, or flourishes in them in the directions mentioned, survives and flourishes either through the survival of free minds or through the persistence of acquired habits. But these latter gradually weaken for lack of sustenance and replenishment and through the passing of the human beings who possess them. Meanwhile none of the new formulas or ideals is allowed to defend itself in orderly discussion, to justify itself by critically tested arguments, by interpretations of history, in a word by perspicacious, cautious, sober research. It is forced to drone its arid mechanical assertions over and over again, without variations, without proofs, without elaborations, deriving such animation as it can from an accompaniment of threats" (p. 57). The intellectual equipment we need as defenders of freedom is to understand the nature of social and political freedom, the historical circumstances that have favoured its development, how much we have of it now, and what is necessary for its preservation and extension. These are the topics discussed in this book.

There is a widespread and dangerous belief that the obstacles to freedom are incidental difficulties

easily put right by some simple change in State organization. As Prof. J. Macmurray provides a much-needed corrective, his essay is worth considering specially, even if it means neglecting other excellent contributions. Freedom, he says, "as we experience it resides in the adequacy to our purposes of our powers, opportunities and means" (p. 178). Constraint, its opposite, is of various kinds but the only one of importance is that imposed by the clash of human wills. When something that is otherwise possible is rendered unattainable by the opposition of another person, it is felt and resented as oppression. While increase of scientific knowledge has rendered many things possible which in the past were objectively impossible, human relations have been such that many possibilities have not been realized. Thus increase in power has meant actual diminution of freedom. The main source of trouble is that human relations are of two sorts, depending on the kind of motives involved. If two men are partners in business, the important fact about the partnership is its purpose. If the purpose is accomplished or found to be unattainable, there is no reason for that partnership to continue, as it is only a means to an external end. The success of the partnership depends only slightly upon any personal affection or animosity the partners feel for one another. Indeed it is not necessary for them to meet or know each other or communicate except on business. This kind of relationship is the sphere of economics and politics, and gives rise to 'society'. But if two men are friends the relationship is quite different. Though they may have a common purpose and be partners in business, it is pointless to ask what is the purpose of the friendship. This is the kind of relationship that gives rise to 'community'.

"In the nexus of personal relationship community is capable of generating and containing society within itself, of making co-operation for the achievement of common ends a means to itself and an expression of itself. Therefore it is clear that if the problem of community is solved the problem of society will be well on the way to solution" (p. 188). Society, on the other hand, can exist quite independent of community. It is also more permanent and powerful. As personal affections and animosities hamper rather than promote social organization, society is apt to demand from its members loyalty to common ends overruling private ends. It also tends to treat its members as means only. Struggles for freedom have been mainly attempts to change the organization of society, with disappointing results for the most part. Prof. Macmurray concludes pessimistically that there is no technique of freedom. In other words, liberty and equality are empty forms without fraternity, and there are no rules for achieving this.

There is no doubt Prof. Macmurray is right in saying that by itself society can generate tyranny but not freedom. Still, it is possible that his pessimism goes too far. He may be looking too exclusively at the debit side of society and the credit side of community. Granted that love and affection are the basis of community, it was these that produced the blood feud. There has been no greater single human achievement than that by which an act of violence, which was once a private wrong to be avenged on the family of the agent by the family of the sufferer, has become a breach of the King's peace. This is the means by which we are free to walk abroad unarmed, to leave our doors unlocked and to sleep in our beds without fear (except for acts of the King's enemies). Society has stepped in to prevent community destroying itself. An even greater attempt, never completely realized, is the Roman notion of the equality of all before the law, in place of one rule for ourselves and our friends and another for outsiders. Law is the only final safeguard of freedom, but it does not work automatically; it needs active support and criticism, such as society cannot produce. Prof. Salvemini rightly emphasizes the democratic virtue of humility, because humility is needed for tolerance. But this is one thing the democrat cannot tolerate, so that he needs the contrasted virtue of vigilant sympathy that will not stand by and see injustice done.

A. D. RITCHIE.

THE LABORATORY MOUSE

Biology of the Laboratory Mouse

By the Staff of the Roscoe B. Jackson Memorial Laboratory. Edited by George D. Snell. With a chapter on Infectious Diseases of Mice, by J. H. Dingle. Pp. ix+497. (Philadelphia: The Blakiston Company, 1941.) 7 dollars.

THE Roscoe B. Jackson Memorial Laboratory in Bar Harbor, Maine, celebrated its tenth anniversary in 1939. During this short space of time, the staff of the laboratory, under the leadership of Dr. C. C. Little, in addition to numerous important investigations, has carried out a task which puts large sections of medical research deeply in their debt. The primary object of the laboratory is cancer research; Dr. Little and his team realized very early that many phases of this problem cannot be tackled successfully without bringing the genetic variables under control. A homogeneous strain of animals can be produced by continued close inbreeding. But a single pure line would be of very limited value; so the laboratory set out to establish a large number of inbred strains of mice differing widely both in the incidence of tumours and in the type of malignancy to which they are prone. But this 'variety of uniformity', unique in mammals, is also an almost untapped source of material for the study of innate and environmental factors in nearly any conceivable phase of mammalian biology and pathology. It would be difficult to muster a more competent team to write a biology of the mouse than the staff of the Jackson Laboratory.

The book under review brings together most of the scattered information on the mouse as a laboratory animal and contains more than 1,100 references. But it is more than a compilation. Some of the sections are based on research specially undertaken to fill in gaps in our knowledge, and unpublished data on many subjects are scattered throughout the work. The book opens with a clear and well-illustrated section on early embryology (54 pp.) by G. D. Snell, followed by a chapter on reproduction (33 pp.) by the same author. Histology (79 pp.) is treated by E. Fekete with numerous excellent photomicrographs. Beautifully illustrated is also the section on spontaneous neoplasms (66 pp.) by A. M. Cloudman, which is followed by a short account (14 pp.) on gene and chromosome mutations by G. D. Snell. Dr. C. C. Little contributes chapters on the genetics of spontaneous tumour formation (31 pp.) and of tumour transplantation (31 pp.) respectively; neither of these sections is exhaustive, but it was probably a wise decision to abstain from monographic treatment of a subject so much in flux. Short sections

on endocrines and tumour formation (11 pp., G. W. Woolley) and the "milk-influence" in tumour formation by its discoverer, J. J. Bittner (4 pp.), are followed by a useful discussion on the value of inbred and hybrid animals in research (W. L. Russell, 24 pp.), which is addressed to the non-geneticist and should go far to clear up common misunderstandings. Parasites are treated by W. E. Heston (31 pp.) and infectious diseases very extensively (95 pp.) by J. H. Dingle, of the Harvard Medical School. A short section on care and breeding (J. J. Bittner, 5 pp.) and an adequate index conclude the book.

The contributions are generally well written and excellently illustrated. It will be indispensable to all workers who use the mouse as an experimental animal, and to students of cancer in particular. I have noticed only two slight errors. The root of the upper incisor does not reach so far back as the molar region (p. 110), and the gene for hypotrichosis juvenilis does not overlap normal (p. 241). HANS GRÜNEBERG.

NEW CYTOLOGICAL TECHNIQUE

The Handling of Chromosomes

By C. D. Darlington and L. F. La Cour. Pp. 166+16 plates. (London: George Allen and Unwin, Ltd., 1942.) 8*s*. 6*d*. net.

THE study of chromosomes is a branch of biology which has expanded very considerably in the last fifty years and has recently acquired an extended popularity owing partly to its association with genetics and partly to an increased technical facility which has been gradually built up from the accumulated experience of many workers. The modern microscope, perfected at the end of the last century, and the use of the microtome were understood before the War of 1914–18 and have not been improved appreciably since. On the other hand the last twenty-five years have added the smear techniques associated with the use of rapid and transparent (but often transient) stains, which can also be applied to extend the use of the microtome to very thick sections. Some improvements have been made in the formulæ of fixatives and, for certain purposes, by using reagents such as acetocarmine and rapid macerating treatments involving hydrolysis with hydrochloric acid, it is now possible to see in a few minutes things which a generation ago would have necessitated a delay of several days. In other cases whole fields of new observation have been opened up by the development of special methods such as those now available for the demonstration of spiral structure. The most recent innovation, and one which is certain to be further extended in the future, is the application of specific chemical reactions such as selective digestibility and microchemical colour tests such as Feulgen's reaction to the study of chromosome structure.

In an expanding science, some guide to new technical advances is needed from time to time and the part which Darlington and La Cour's little book could fill is obvious. Whether it in fact does so is less certain. Much useful information is undoubtedly contained regarding new methods, some of which are indeed published here for the first time. For this the cytological specialist will be grateful though he may perhaps resent some sweeping generalizations and a tendency to over-simplify, for example, the labelling of Caspersson and Hillary's lanthanum acetate trypsin method as "precipitation and digestion of nucleic acid" (p. 57), when the essence of it is precipitation of nucleic acid and digestion of protein.

The book is, however, not primarily addressed to cytologists but to "teachers and students in school and university". Presumably for their benefit space has been given to elementary instructions on how to write a paper (Chap. 12) and to drawings of common utensils such as slides and staining jars (pp. 126–7). The uninformed reader would, however, go away with the impression that all cytology is very new and very easy and that he need know little or nothing about information available before about 1920. This appears to the present reviewer to be a great mistake. The modern developments amplify, but do not by any means eliminate, the usefulness of the older achievements. Sound microscopy is still the keynote of successful cytology and a student can profit very greatly by learning to use old equipment such as the paraffin oil microscope lamp, and by careful perusal of an old and classic handbook on the microscope such as that of W. H. Carpenter (eighth edition, 1901, still available in most reference libraries). It is doubtful whether he could acquire even the minimum of necessary information on the use of the microscope for high powers from the very brief and somewhat peculiar paragraphs devoted to it in the book under review; though he might easily be confused by references to the numerical apertures of lenses and condensers, made without explanation of the term, and to discussion of the relative merits of different resolving powers when these are expressed merely as microns (p. 24).

It is difficult to see what class of reader could benefit by perusal of the chapter on photography, and the price of the book has certainly been enhanced by the inclusion of large photographic illustrations using magnifications up to ×10,000 although it is physically impossible, with visual light, to obtain any image of detail finer than will reproduce in half-tone at a magnification of ×3,000, and for scientific (as opposed to artistic) purposes even this degree of enlargement is generally excessive. The difficulty of using an old (and valuable) stain such as hæmatoxylin is stressed but it is trivial in comparison with that of applying polarized light to chromosomal problems, yet a student would receive exactly the contrary impression from the descriptions given—the property investigated by the latter method is, incidentally, not "rotation of polarized light" (p. 32) but birefringence, that is, the property which a chromosome may or may not possess of splitting a beam of polarized light into two beams polarized at right angles.

It is not difficult and it is sometimes desirable to cut sections thinner than 14 μ, but a student's troubles would be magnified by making him use only an extremely hard wax of m.p. 58° C. for such a purpose (p. 48), for, in temperate climates, almost all cytological material, in plants at any rate, will cut satisfactorily in m.p. 52–54° C. at thicknesses of 6–14 μ and extra hardness is only needed for exceptional specimens or for thicknesses of 4 μ or less.

To meet adequately the requirements of a student or inexperienced teacher, much greater care would need to be expended on the accuracy and balance of the matter to be presented. For a more experienced reader, on the other hand, much will be redundant and emendation of details will be necessary, but a solid core of real value remains if the book is treated as a source of introductory reference to some interesting, new and useful laboratory methods. To

be more precise, it is worth buying for the sake of some of the notes contained in the appendixes and for some of the information summarized in the chapters dealing with the making of smears and squashes, with the handling of special tissues such as pollen tubes, embryo sacs and salivary glands, and with the application of special agents such as X-rays, drugs and the various treatments for spiral structure.

I. MANTON.

PRECOLOMBIAN HAITI

Excavations in the Ft. Liberté Region, Haiti

By Froelich G. Rainey

Culture of the Ft. Liberté Region, Haiti

By Irving Rouse

(Yale University Publications in Anthropology, Nos. 23 and 24.) Pp. 48+196+35 plates. (New Haven, Conn.: Yale University Press; London: Oxford University Press, 1941.) 21*s*. 6*d*. net.

THESE two papers, issued as a single volume, give an account of the culture of a small area in the north-east corner of the Republic of Haiti, and of the excavations on which it is based. With one exception, the sites lie within an area measuring about 7 km. by 5 km., and the remaining site is about 10 km. farther east.

The first paper is an admirably concise account of the excavations by Dr. F. G. Rainey. Eleven sites were investigated, all of them shell middens. Five of these yielded a culture characterized by flint implements without pottery, burials or defined hearths; the remainder, which were somewhat larger and thicker, though the maximum thickness of deposit was only about 1·5 metres, contained pottery. Of these, four were assigned on the basis of their pottery type to one culture, called the Meillac, and the other two to another, with a different type of pottery, called the Carrier. A few primary burials were found in the middens on Meillac sites: they were in poor condition, but appear to have been in a flexed position, and in two cases were accompanied by pots. No other grave goods were found. There was also evidence of secondary burial. There was no stratification which threw light on the relative ages of the cultures on any of the sites, but a small admixture of Carrier pottery was found on three of the Meillac sites.

The paper is illustrated by two maps, both of which have been reduced too much, a criticism which applies particularly to that of the Ft. Liberté Region, which also lacks a scale. The remaining figures are plans and sections of the sites. These are perfectly clear, but the vertical scale has been exaggerated as much as ten times in several cases and forty in one. Where possible, it is better to draw sections true to scale: the amounts of exaggeration cited are in any event excessive.

The second, much longer, paper, by Dr. I. Rouse, is an account of the cultures. He classifies them into four periods. The first, comprising Rainey's flint sites, is occupied by the Couri Culture. Period 2 is a blank separating the Couri from the Meillac Culture, and no evidence for its existence is presented. Presumably it is based on the absence of any admixture of Meillac objects on Couri sites, but this is not an indication of any value when the small size of the area studied is considered. Period 3, with its four sites of the Meillac Culture, is divided into four subdivisions. The evidence for this appears to have been presented in a previous paper by the same author, but the value of these minor periods is on the face of it extremely dubious. Period 4 comprises the two sites of the Carrier Culture.

There is no reason to doubt that the Couri Culture is the earliest, but the question of the relative ages of the other two is more difficult and may not yet be finally settled. The author says that he demonstrated the greater age of the Meillac Group in his previous paper "by distributional and statistical methods", but their merits cannot be judged since the paper is not available. He believes that the Carrier type of pottery originated in the Dominican Republic when the Meillac type existed in the Ft. Liberté region, and that the Carrier type, which is the more sophisticated, replaced the other by diffusion. It seems likely that this explanation is correct.

Dr. Rouse's account of these cultures could scarcely be fuller, but it is difficult to read and excessively long owing to his method of presentation. He is trying to introduce a definite procedure for classifying culture and in doing so he uses a lot of terms which are not likely to command wide acceptance. In his desire to apply his system throughout the work he involves himself in much unnecessary repetition and many glimpses of the obvious. The term 'mode' lends itself particularly to this sort of thing. Absurd 'modes' are legion, but one list must suffice as an example. After a detailed description of the petaloid stone celts (in the course of which we are told that they are relatively heavy, rigid and hard !), we find the following conclusions on p. 95: "The following are the modes for petaloid stone celts: igneous rock, metamorphic rock, dullness of the rock, bright greenness of the rock, flaking (?), battering (?), grinding, polishing, resharpening, high surface polish, petaloid shape, pointed butt, convex sides, convex edges, semicircular bit, large size, small size, use for chopping, and ceremonial use. . . ." The conceptions of "alternative" and "optional" modes do not seem to clarify the descriptions, and it is difficult to see what purpose is served by the numerous tables giving "alternative and optional relationships of the modes", etc., particularly when they contain column headings like the following: "No overall shape", "No body", "No aperture", in a table dealing with open bowls. They appear to represent an abortive attempt to reduce classification to a mathematical basis, and they would have been better omitted.

Appendix I consists of a detailed report by specialists on a technological analysis of Meillac and Carrier sherds, in the course of which they state definitely that there is no evidence of artificial tempering. In spite of this, the author discusses the whole question afresh on p. 55 and suggests the same conclusion as "mere conjecture".

The plates consist of excellent photographs of the objects, of which there are plenty of examples. There are, however, several numerical mistakes in the references to them in the text.

The final chapter is an attempt to relate the cultures to others in the West Indies. It contains thirteen pages, of which more than seven are occupied by tables, most of which do not add any useful information to the work. The result of it all is to show that the Meillac and Carrier Cultures have been proved to exist elsewhere in Haiti, but that it is premature to try to correlate them with anything farther afield, a fact which is clearly demonstrated by the high proportion of space occupied by queries in the final table.

G. H. S. BUSHNELL

THE VALUES OF SCIENCE TO HUMANITY*

By PROF. A. G. TANSLEY, F.R.S.

TO most people to-day the word science suggests, first of all, the marvellous modern applications of science to human use. Such inventions, yearly increasing in numbers and in scope, have enriched human life not only on its material side, but also indirectly, in æsthetic, intellectual and spiritual aspects. By quickening every sort of intercommunication they have put the most widely separated products of human thought and creativeness at the disposal of everyone. By 'annihilating time and space', as the vivid phrase goes, they have drawn the peoples of the world together.

It is tragically true, of course, that scientific inventions have also placed enormous means at the disposal of those men of evil will who have seized power in their own countries and have taken advantage of the deficiencies of international organization to disrupt and overwhelm neighbouring States. Shallow and thoughtless critics have blamed science and men of science for these catastrophes. They should rather have blamed man's failure to develop an adequate ethical standard in international relations, his failure to acquire that sense of human solidarity with which the race can no longer dispense if it is to survive under tolerable conditions. Not science but lack of morality is the culprit. Man's material power has altogether outrun his ethical development. It is as impossible to check scientific discovery and its application to human purposes as to stop an inflowing tide. What those purposes shall be must depend on the degree of man's spiritual development, on the values in which he really believes.

The primary motive that prompts a man to learn and practise science is the desire to obtain organized knowledge of the objective world around him. Such knowledge may be sought for its own sake or for its practical usefulness. When the former motive is predominant we have been accustomed to speak of 'pure science', as contrasted with 'applied science' when scientific knowledge and scientific method are used for the solution of practical problems of human life. The devising, improvement and elaboration of technical methods of dealing with materials and processes for practical ends may best be called 'technology'. But we are told by an increasingly vocal school of scientists turned publicists that there is no real distinction between pure science and technology, that the root of man's interest in knowledge of the natural world is the use he can make of it, and that pure science is either the theoretical formulation of knowledge originally sought for purely practical ends or, when it is not this, a form of recreation which is at best harmless if it does not divert attention from more serious and useful pursuits.

The essence of science is said to be the acquirement of power over Nature. Science has been actually defined as "the system of behaviour by which man acquires mastery of his environment". We had supposed, until we were thus instructed, that science meant a kind of knowledge, not a kind of behaviour. Indeed the most elementary thinking about the human mind and human activity would seem to require a primary distinction between knowing and behaving.

But if we pass over this extraordinary misuse of ordinary language we are confronted with two contradictory views of the status and function of science —on one side the view that science is a body of knowledge primarily concerned with the effort to satisfy human needs, 'pure' science, so far as it may be entitled to recognition at all, being an offshoot, so to speak, of this body of knowledge; and, on the other hand, the view that pure science is a primary body of knowledge and theory, which has no necessary relation to practical needs, but much of which may be applied to those needs with far-reaching effects. What is the explanation of this contradiction? I think it may be found in the confusion of historical and psychological points of view. Historically, pure science may fairly be said to 'emerge from' a body of knowledge much of which is empirical and technological. Psychologically, pure science, as it exists to-day, has a completely independent status, and incidentally is the source of all significant technological advance. Let us consider this matter in some little detail.

That the kind of knowledge we call science leads directly to increased power over Nature, that it is the source of our wide and powerful modern control over the materials and forces of the external world, is obvious to all. Primitive man got the first glimmerings of the foundation of scientific knowledge—that similar causes produce similar effects—in the conditions of his hard daily struggle to maintain himself and perpetuate his race in a hostile or at best an indifferent world. Such knowledge was purely empirical knowledge. Fire burns, but it will also cook food and scare off wild beasts; water drowns, but it also quenches thirst; sharp flints can be used as weapons and also as tools, and so on. Empirical knowledge is not science though it is the indispensable basis of science. A good many writers are in the habit of using the words 'science' and 'scientific' for *all* knowledge gained by primitive man, and in the earlier civilizations, about his material environment, simply because it related to the objects and processes which now form the subject-matter of branches of science such as physics, chemistry, geology and biology. Most of this knowledge was purely empirical. Science does not come into existence until some kind of generalization is formed in the mind, a generalization that can prove its validity when it is applied to new phenomena.

The transition from purely empirical knowledge to the first rudiments of scientific knowledge was no doubt an imperceptible transition. We do not know and can never know the times and places and ways in which the first ideas which can properly be called scientific arose out of the bodies of empirical knowledge. We shall be safe in giving the first place to the general notion of causation, an essentially abstract conception which underlies all the rest. The causal nexus between happenings could not fail to impress itself on the primitive human being experiencing the events of his daily life. That *B* happened *because A* had happened must have been a very early thought.

There is no evidence and no likelihood that the basic mental equipment of primitive man—at least of men of our own species from Upper Palæolithic times—was substantially different from our own; but he was without our *heritage* of knowledge. He had to begin from the beginning, from the platform of adaptive instincts built up by and inherited from

* Extracts from the Herbert Spencer Lecture delivered in the University of Oxford on June 2, 1942. The complete lecture is published by George Allen and Unwin, Ltd., 1s. 6d. net.

his sub-human ancestors. But he had in supreme degree the power of adaptation and intelligent modification of those instincts to new conditions of life, and with the acquirement of the power of articulate speech he could initiate an oral tradition of knowledge. Thus bodies of traditional knowledge were established, handed on, and gradually increased from generation to generation, varying according to the different environments in which different human groups found themselves. These bodies of empirical knowledge necessarily related primarily to the vital needs of the group, and so it has been throughout the hundreds of millennia of man's history. Equally in pre-glacial times, when man first began to emerge from among his ape-like ancestors and in our twentieth century of the Christian era, equally in London and in Timbuktu, the individual *must* acquire the knowledge immediately necessary to his continued existence, however widely different the content of that knowledge may be.

So it is also with the aggregate knowledge of a particular human group or community. Those communities which had acquired the particular type and degree of knowledge and skill best adapted to their particular environment were the most likely to survive; and when they came into competition or open conflict with others, those communities would win whose knowledge, skill and material equipment best fitted them for success in the struggle, because the environment of each community included the incidence of its competitors.

How far did primitive man seek objective knowledge of Nature for its own sake, besides acquiring the knowledge essential to his existence? That, of course, we can never know with any approach to certainty. But it is significant that unspoiled savages to-day show at least as much interest in natural phenomena which do not affect their material interests as does the man in the street of a community which is called civilized. Since curiosity is certainly a primitive human instinct, and it leads to the acquirement of knowledge which is independent of practical usefulness, we can scarcely doubt that such knowledge was sought from a very early period of human history. But pure science cannot attain any considerable development in a society with little leisure. Where the conditions of life are so hard that everyone is almost wholly occupied in keeping body and soul together there is no time or mental energy available for the acquirement and organization of much knowledge for its own sake. In such conditions the great bulk of the knowledge that is acquired is practical knowledge, how to secure and extend control over that part of the environment which is of immediate practical significance, and then to make life easier and more comfortable. Thus arose the arts of food-gathering, of hunting and fishing, of stone implement making, of the taming and training of animals, of primitive agriculture, of weaving and pottery making, of building and primitive metallurgy. Chance observations, hit and miss experiments, the use of experience and primitive inductions, must have been the means employed. The improvement and elaboration of these various arts were the foundations of technology.

With the attainment of settled conditions and the advancement of technology, surplus wealth, that is, stocks of commodities not required for immediate use or consumption, could be accumulated, trade could develop, comfort could be increased, and eventually the luxury created which has been so marked a feature of the more elaborate civilizations. At the same time leisure became more abundant, at least for some members of the community. The arts of writing and of calculation were invented, and geometry and astronomy began to emerge as coherent bodies of knowledge. Practical needs such as trade, craftsmanship and the making of calendars were no doubt the immediate stimuli to these developments; but since we have every reason to believe that the mental constitution of the races which have occupied the Near East and Europe during the last four thousand years has been essentially constant throughout, it is impossible to doubt that the satisfaction in discovering new knowledge for its own sake, which is the driving force of research in pure science, must have been present in those early civilizations of the great river valleys of the Near and Middle East just as it was probably present in much earlier savage ancestors.

From at least the sixteenth or seventeenth century onwards there has been a body of scientific knowledge and theory which had *continuity*, and each generation could build upon the foundations laid by its predecessors. Discovery in science, hitherto isolated and sporadic, became a continuous process, and thus pure science, cultivated for its own sake, acquired an independent life. Needless to say, it was often influenced in volume and direction by social and economic as well as by intellectual conditions, and it often took technical problems as starting-points. But it was never wholly determined by such influences, and a great deal of it was undertaken with no reference whatever to the usefulness of its results. It is such research, in fact, that has ultimately led to the most striking practical discoveries and inventions. It is a striking fact that many discoveries made in the course of work undertaken with no practical aims have unexpectedly turned out to be keys to important applications of science in wholly different spheres. As scientific knowledge and theory become increasingly complex all sorts of cross-connexions between different departments reveal themselves, new branches arise, occupying hitherto unexplored ground between the older fields, and others cut across the old boundaries and take their material from several such fields. For this reason alone—the unexpectedness of discoveries and the unexpectedness of their applications—it would be disastrous to attempt the direction of all research to specific practical objects or to hamper complete freedom of investigation.

At the same time we must recognize that a good deal of work in pure science is unlikely ever to be of any practical use, though it may be of the greatest interest. Such, for example, is the detailed *history* of the earth, of its rocks, its vegetation and its animal life, and also a great deal of the detailed morphology of the plant and animal kingdoms. Should we discourage such work or deny it the necessary facilities? There are at least two good reasons why we should do nothing of the kind. In the first place we could never safely draw the line between work which might prove materially useful and work which certainly never would. If we once began to draw such distinctions we should put science into the power of those who clamour for results of immediate practical use and have no understanding of the complex and vital inter-relations of its different parts. The second reason goes much deeper, though it is connected with the first. Any such restriction of research would deny the right of

men of science to investigate and increase our knowledge of the *whole* phenomenal world, and the right of the individual man of science to choose the field which his abilities and inclinations best fit him to explore.

The immense and complex development of pure science has the most far-reaching applications to human activity and profound effects on technology. Separating out, as we have seen, from the undifferentiated body of scientific discovery and technological invention of a former age, and acquiring an independent life of its own, pure science became the main source of all fundamental technological advance, while its full potentialities of application to other fields of human life are just beginning to be realized.

Historically, then, scientific theory arose piecemeal in one field and another, emerging from the growing structure of practical empirical knowledge or from the independent study of Nature. Gradually the separate pieces coalesced and began to form coherent bodies of theoretical knowledge. As it became securely established the structure of scientific theory acquired an independent existence and its description as 'pure science' became justified. On every hand it fertilized technology and made possible great advances and entirely new developments in the most various technological fields. Thus the term 'applied science' began to be used for the applications of pure science to the practical purposes of human life. Once established as an independent human activity, pure science assumed a continuity and a universal status which technology can never have, simply because all but the most elementary material human needs are partial and variable, so that human arts and crafts and manufactures rise and fall, appear and disappear, while organized knowledge of the world of Nature is permanent and free from such fluctuating conditions.

Technology is essentially 'patchy': technological research is occupied in solving unrelated practical problems of technique in the most various fields of human activity. Deeper penetration to underlying causes is not, as a rule, any concern of the technologist. All he cares about, as a technologist, is the solution of his immediate problem. The pure scientist, on the other hand, is perpetually seeking underlying causes, relations between things previously unsuspected of being related. This constant search is the essence of pure science, and when it succeeds great new fields are often opened up for exploitation by the technologist.

Recent writers who have envisaged not only technological but all scientific work as a 'social activity' determined by current social conditions and directed to the satisfaction of current social needs, have had no difficulty in demonstrating the general correlation of work that may be described as scientific with social structure and social requirements at various times and places. But to justify their sweeping conclusions they have had to lump together the whole body of empirical, technological and pure scientific knowledge of Nature and of human arts and crafts acquired throughout the ages; and they have misrepresented with a strange perversity the real nature and the essential psychology of scientific research. Up to the seventeenth century research for the sake of pure knowledge was on the whole sporadic, and the great bulk of the work described as determined by social conditions was technological work, though great scientific discoveries and generalizations were made here and there. Since then, as pure scientific work began to coalesce and acquire continuity, the determination of its direction by purely social factors has become less and less marked.

Leaving now the historical development of science we turn to the essential psychology of scientific work of various kinds.

No one contends that scientific men who engage in research are entirely uninfluenced by the social conditions of their time or by the particular conditions of their own early life and environment. It is obvious enough that these conditions must have a great effect on the formation of the scientist's mind and therefore on all his activities. The individual human mind has a certain specific hereditary endowment, but it does not work *in vacuo*. The material with which it is fed in childhood and youth and the influence of its particular environment must play a large part in determining its future activity.

The actual motives, both conscious and unconscious, which may cause a man to-day to embrace a scientific career of any sort are various and of different orders; the same, of course, may be said of any other human activity. For the vast majority there is the over-riding necessity of earning a living, and the particular work or career adopted will obviously depend on opportunities and prospects. A century ago a 'career' in science was open only to a very few. To-day opportunities are numerous and increasing, owing partly to the rapid growth and development of pure science but mainly to the enormous extensions of applied science and technology. The great majority of these openings lead only to laboratory posts the duties of which are those of what is sometimes called 'routine research', that is, to the making of tests, trials and checks on the instructions of a superior. A smaller but still a considerable number of posts are available in teams of research workers in industrial or Government laboratories engaged on the attempted solution of technical problems or sometimes of problems in pure science which are thought to have a direct or at least an indirect bearing on technical progress. This again is 'directed' work, just as much as that of a clerk in an office, though its intrinsic interest to the scientifically minded may well be much greater. To a few comes the possibility of promotion to the position of a subordinate director of the technical work of others or to the headship of a research team, and a very few may become directors of scientific departments or institutions where they will have much more opportunity of initiative, though very commonly such appointments are not made from the personnel of the particular laboratory, but often go to people from outside with a different sort of training. It is obvious, then, that to the vast majority of 'scientific workers' only technological work in which there is little freedom or opportunity for initiative is available.

There remains the possibility of employment in the teaching of science as a schoolmaster or at a university. A few schoolmasters find time and inclination for independent research, but the conditions are not often favourable. On the other hand, academic science teaching is usually combined with research and most of the current research in pure science is actually done at universities, much of it by university teachers.

Probably most of those who adopt one or other of these scientific careers—certainly those who enter the last-named—in order to earn a living have to a greater or lesser degree what is called the 'scientific bent'. This shows itself either as a strong interest in

and desire to obtain organized knowledge of the natural environment—more often of some particular part of it, such as stars, rocks, animals, or plants—or as a specific interest in 'how things work' commonly seen in a small boy's keenness to find out how a machine is constructed and how its parts act.

What are the psychological factors underlying the 'scientific bent'? 'Curiosity' is the most general concept under which the first impulse to both kinds of scientific interest—in environment and in working mechanism—may be brought. Curiosity has been defined as "the desire or inclination to learn or know about anything, especially what is novel or strange". This is the adult expression of the curiosity which may fairly be regarded as a primary instinct of many higher animals, and is conspicuously displayed by human beings from a very early age. The human infant expresses it by making sensory contacts with the unfamiliar objects of its immediate environment, through sight, smell, taste, touch and manipulation. This is the primitive means of 'getting into touch with' or acquiring knowledge of one's surroundings.

The promiscuous curiosity of the young child, if it is not smothered by overwhelming repression but is controlled and canalized by the direction of intelligence, under the influence of growing experience, develops into the desire for organized knowledge of the objective world around him. This may take either or both of the two forms we have already distinguished, leading to interest in the 'natural history' sciences or in what has been called "general analytical science". Much can be learned from books and from oral teaching, but the unblunted instinct can be directly satisfied only by independent observation and experiment. It is the satisfaction by talented people of the desire for organized knowledge of the objective world that has gradually built up the permanent structure of pure science by successive descriptions and discoveries and by the conceptual welding of these into coherent bodies of scientific theory, the parts of which are constantly modified or replaced as fresh discoveries are made or deeper insight gained into the relations of phenomena.

The consistent object of pure scientific research is to establish a coherent body of objective knowledge and explanatory theory over the whole range of natural phenomena. In the course of this work new phenomena come to light, often by chance, and some of these can be exploited industrially. At the same time new principles are established which give rational direction and lead to crucial improvements in industrial processes that had hitherto been purely empirical. It is naturally physics and chemistry that have had the most extensive use in the field of technology, because industrial processes deal mainly with dead material. But biology has made important contributions to the two great practical arts of medicine and agriculture, and we are now on the verge of far-reaching social developments in which the applications of biological and psychological knowledge will play a commanding part.

We must not underrate the scientific importance of the enormous amount of work that is now done in technological laboratories attached to industrial firms, instituted or assisted by Government, and sometimes attached to universities. Not only is it necessary to improve and perfect established industrial processes and to learn how to exploit new scientific discoveries on an industrial scale, but also in the course of such work new scientific problems emerge which have to be solved if further advances are to be made. Some of these problems can be tackled in the technological laboratory itself, others are remitted to laboratories of pure science. Some technical laboratories, indeed, though founded solely for work in applied science, do in fact spend part of their time in pure scientific research on problems chosen from the particular field. Thus pure science and technology act and interact to the advantage of both, and so it must always be. While insisting on the essential distinction between them, we must not forget that the two are in one sense parts of a whole —a whole which has a fundamental unity given by the consistent application of the scientific method to every sort of problem, whatever the material and whatever the object. But the immediate object, which carries with it the specific motive, does determine the nature and scope of the results.

We have defined pure scientific investigation as the pursuit for its own sake of coherent knowledge of the phenomenal world, and the essence of its being is psychological. The motive actually at work here is nothing else than scientific curiosity, the satisfaction of which is the discovery of new objective truth—of new facts which can be fitted into the framework of pre-existing theory, which require its modifications or restatement, or which demand new theoretical formulations. Technological research has other primary motives. It is always concerned with the solution of a problem for practical purposes. Behind it may lie the motive of making increased profits, or the motives of saving labour, of curing or preventing disease, or of promoting the health and well-being of the population. Several different motives of this kind may be involved at one and the same time, but they are all concerned with direct practical ends.

We must recognize that human motives are often, if not generally, mixed. A man may want to benefit humanity and at the same time to increase his income, and the two very different impulses may be served by the same action. He may also at the same time be moved by genuine curiosity about the solution of his practical problem and experience the joy of discovery when he is successful. The professional scientist, entirely devoted to his research with the unique object of discovering new fragments of truth, cannot ignore the necessity of earning his living. If he were no longer paid he would have to find other employment. But these facts do not affect the truth that the structure of pure science has been built up by men who sought knowledge for its own sake without regard to practical ends, and the further truth that without their work modern technology would never have been possible. If the disinterested pursuit of knowledge were to cease, the structure of science would cease to grow and the springs of all fundamental advance in technology would be dried up. That is one reason why we must uphold the claim of free research in pure science to an assured place in our society.

But it is by no means the only one. Science is indispensable to our complicated material civilization: it has also intellectual, ethical, æsthetic, and ultimately spiritual values of a high order. In the first place, its constant touch with the world of external Nature in which laws are at work that are uninfluenced by the vain imaginings of human beings keeps our feet on the ground, and should help to check the constant human tendency to fly off into ideological fantasies and to imagine that subjectively constructed and emotionally biased ideal schemes

can without more ado be successfully applied to the real world—a tendency responsible for a large number of disastrous political mistakes. I am far from contending that objective sanity is the monopoly of men of science. On the contrary, there is unfortunately abundant evidence that employment in scientific work and even distinction in research is no assured safeguard against domination by misleading idealisms. But there can be no doubt that the scientific habit of mind, with its insistence on preliminary careful and accurate survey of facts and its constant testing of theory by fresh observations and experiments, is the master key to the devising of successful techniques not only in the material but also in the social and political spheres.

One of the best hopes for the future welfare of humanity is the beginning of unbiased investigation of social facts, of social psychology as well as what may be called social anatomy and physiology, and the influence upon these of economic and other environmental factors. The great man after whom these lectures are named clearly saw, sixty years ago, that we needed a real science of society which he proposed to call 'sociology', but it is only recently that the study has begun to assume a genuinely scientific character. Its development is seriously hampered because its field is also an arena of the strongest human prejudices and passions, as the older sciences are not. For many of us an impartial consideration of the facts revealed is very difficult indeed, because our feelings and our private interests are too deeply involved. Ideological constructions, of which the Fascist and the Communist theories of the State are current examples, gain numerous adherents because they satisfy certain human ideals and seem to provide remedies for current evils. In some countries they have been imposed by force, since they also serve the interests of ambitious individuals. Behind a façade of pseudo-philosophy or pseudo-science are concealed gross inconsistencies and often gross cruelties. Yet we must recognize that aspects of sociological truth inhere in the most extreme social and political theories, or they would not appeal, as they do appeal, to so many people of goodwill. For it must never be forgotten that every social theory that appeals to people of goodwill contains at least some element which corresponds with a deep-seated social need, however far it is from being acceptable at its face value.

It is the business of the new scientific sociologist to evaluate these elements in the light of social and individual psychology, as well as to accumulate, marshal, and determine the significance of the widest range of sociological, economic and political facts. It is the ultimate business of our statesmen to implement their mature conclusions. Statecraft, like agriculture and medicine, is a very ancient art, and on one side it must always remain an art. Human beings cannot be managed entirely by text-book rules, however good the text-books. But just as agriculture and medicine have become and are still becoming, to their immense benefit, increasingly scientific, by the discovery of the laws underlying the processes involved in the growth of crops and in the human body in health and disease, so the organization and management of human populations, which is the concern of statecraft in its widest sense, can be made increasingly scientific by the proper use of sociological and economic data. The making and still more the application of sociological generalizations demand bold constructive imagination but at the same time the greatest caution and the coolest judgment, precisely because they are so easily influenced and distorted by our prejudices and passions. A certain amount of 'flair', of empirical procedure, and of trial and error experiment are necessary, just as they still are in agriculture and medicine.

We may well ask whether our statesmen are sufficiently equipped for their part of this task, whether their prevailing mentality is of the kind which can freely accept the scientific method and apply it to their problems, whether they are not too hopelessly biased by so-called vested interests, of class, party, or money. This is indeed a very serious question. Ministers and high officials are constantly betraying their indifference to, or their distrust of, the scientific approach to practical problems, even in such matters as agriculture and food values, in which it is clear that only responsible scientists who have made the relevant investigations have any right to an opinion. It is often only under the stress of war conditions that far-reaching changes are made which have long been urgently required and strongly advocated by all informed opinion.

I am not suggesting that these things can be made right by putting scientists into ministerial offices. The professional scientist is no better fitted than any other professional man to deal successfully with affairs, to excel in administration, or to manage human beings. Indeed if he has become eminent in some particular specialized branch of science it is likely that absorption in his subject will have rather secluded him from those contacts with the world which are desirable if not necessary for a successful administrator. Nor would it meet the case to require every prospective minister and public official of high rank to take a course in elementary science! It is not specialized scientific knowledge that is wanted here, but the scientific spirit, an intelligent appreciation of what science really is and what it can do. We may acknowledge that the habit of consulting experts has increased of late years. But in the modern State with its innumerable problems demanding scientific knowledge and investigation, the scientific approach should be a matter of course, and the existing temper of Government and official circles is generally averse from such an approach.

A glaring example is the treatment of agriculture in Great Britain by successive Governments since the War of 1914–18. The basic cure for the ills of British agriculture has been and is the scientific approach to its problems combined with a statesmanlike comprehension of the part the land should play in the national economy not only in producing food, but also in keeping a substantial and contented fraction of the population in contact with the fruitful earth. It is of no use to keep juggling with prices and quotas, or to keep changing the Minister. What is wanted is a man of wide outlook and scientific imagination, who has a general knowledge of the advances that have been made in agricultural research, a readiness to take into his intimate counsels the men who really understand them in detail, and the courage and drive to push through the necessary comprehensive plans. Some part of the appropriate measures have been taken in response to the urgent needs of war-time for an increased native food supply, but they cover only part of the field, and we should like to be sure that they will not be discontinued as soon as peace is proclaimed.

What is needed is a complete change of heart, and

it does not seem that this can be brought about except by a change in education. The current education of the men who are entrusted with the forming of Government policies has almost wholly ignored and frequently despised science. Though giving a grudging recognition to its contribution to their material amenities, many of these men regard science with a mixture of dislike and fear—dislike because it seems to them hostile to the traditional cultural values they accept, fear because they are apprehensive that its tendency is to destroy those values. I am not one of those who depreciate classical or historical education. I should look with alarm at the prospect of severance of our culture from its historical roots—the philosophy, literature and art of Greece and Rome—or from the historical channels through which it has developed. But there is no reason whatever why a liberal education in the old sense should not be extended to include a sound introduction to scientific culture. Time could be found by reshaping the curricula and omitting the unessential. I contend that education cannot justly be called liberal to-day unless it includes an introduction to science and the history of science, simply because science is a vital part of the culture fitted to the contemporary world.

The reformed liberal education that I have in mind must begin in the secondary if not in the elementary school. It should be the normal school curriculum and in the hands of teachers thoroughly imbued with its spirit and significance. It has nothing to do with so-called 'specialization' in science, which at present begins at too early an age and may easily have a narrowing effect on the mind, as can unfortunately be seen in many scientists and technologists who have specialized too early and who tend to despise the other disciplines. Narrowness of cultural outlook is not, however, confined to scientific men. I have heard in this University of Oxford historians and others who are supposed to have had a liberal education express almost incredibly narrow and short-sighted views about the place of science in education.

We have just been considering the essential importance of science and the scientific spirit in the economy and service of the State. But the re-orientation of education I have advocated would do far more than produce a new and better type of minister and high official. It would broaden and vivify the minds of all who experienced it, at least of those at all able to benefit by a liberal education. Equally with literature and art, science has its own contribution to make to the development of the mind, its own distinctive quality engendered by the habit of dispassionate objective investigation and of respect for objective truth. The scientific mentality forbids the unconditional acceptance of views and formulæ represented as authoritative but often motived by traditional bias or by selfish interest. It teaches humility and submission to the logic of established facts, and counteracts the arrogance of human prejudice and wilfulness. This is an ethical as well as an intellectual contribution. I do not contend, of course, that this particular moral quality is confined to men of science; only that it is an essential part of the spirit of science and that the wider diffusion of that spirit will powerfully aid the growth of the virtue.

Finally there is the æsthetic aspect of science, which opens the mind to a far deeper and wider realization of the wonder and beauty of the universe. This is not a trivial claim though it may seem to some old-fashioned. A real and deep æsthetic satisfaction is brought by the constant contemplation of the infinite beauty of Nature, ranging from the galaxies of astronomical space through the marvellous diversity of scenery and of the living beings inhabiting the earth's surface, to the fascinating world revealed by the microscope and the still more minute phenomena dealt with by structural chemistry and intra-atomic physics. The gradual discovery of these things and of the laws which explain their relations, constantly reformulated and made to fit the observed phenomena ever more closely, is indeed a marvellous and majestic story, a story in which the human spirit can find refreshment and escape from the conflicts and tragedies of human life just as it can find escape and refreshment in the finest literature and the greatest music. The very impersonality of the subject-matter of science makes the refuge particularly complete. I recall that the group of men who afterwards founded the Royal Society sought refuge in the peaceful atmosphere of their experiments and discussions from the increasing political tension of London during the conflict between king and parliament. If the fashionable and facile charge of advocating 'escapism' is brought against me, I can only reply that the possibility of 'escape' in this sense is absolutely necessary to mental health and stability in the modern world.

Scientific culture, then, must take its place on equal terms beside the literary and artistic cultures. Entirely apart from its indispensability for the material comfort and the safety and health of modern urban populations, science has intellectual, ethical and æsthetic claims of a very high order. Its achievements are particularly characteristic of our own age. During the last half-century Europe has not produced poets or musicians who can compare with Shakespeare or Goethe, with Beethoven or Mozart, but it has produced several men whose discoveries are equal to the greatest in the history of science and very many of conspicuous talent, though not of genius, who have contributed between them a much larger body of sound scientific work than has been produced in any comparable period of history. Why then, we naturally ask, is science regarded with dislike and distrust by too many cultivated people who are supposed to have had a liberal education, and by the great majority of the population as a rather mysterious, esoteric agency which produces all sorts of marvellous mechanical contrivances but in which they have no part or lot? It is, I think, because scientific education has been kept in watertight compartments and almost exclusive stress has been laid on its material achievements to the neglect of its cultural values.

It may be objected that it would be impossible to give the masses of the population a liberal education in science, that science for the vast majority can never mean more than technical training in some particular branch that is materially useful. But if the hopes of progressive educationists are realized the aim of the future must be to put a liberal education within reach of everyone. It is my contention that a liberal education in any full and worthy sense must include a broad introduction to science, along with the other elements of knowledge and training which develop the mind, widen and deepen its scope, and do all that education can do to produce citizens equal to the opportunities and responsibilities of the future. It is perfectly true that only a minority of

pupils will ever profit at all fully from such an education. A process of sifting must take place in the elementary school and in the secondary school, and only a small proportion of pupils will reach the university. Such a process exists now, though it is very imperfect: in the future we must give the fullest opportunities to all, irrespective of means or social class; but selection corresponding with ability and natural endowment there must always be. It is also clear that specialized training for the work of adult life is necessary, that it must be widely different according to the opening for different kinds of such work, and that it should be adapted to the natural bent and capacity of the individual. A great many pupils have no inclination or ability for scientific work, just as various others have no capacity for music, or for mathematics, or for languages, or for administration, or for craftsmanship. All this, of course, is the merest educational commonplace.

What I am advocating is that all should receive the elements of a liberal education, including a broad and real introduction to science in the secondary school, that for pupils of the greatest general ability specialization should be deferred to a later age than it is at present, so that general education could be carried further and a better and wider culture opened to the best growing minds. In this way a juster balance would be reached between the different aspects of human knowledge and a more secure foundation would be laid for a proper choice of occupation. Science would be placed in its proper light before the eyes of growing youth as one of the great channels through which man's creative powers can find expression, without the almost exclusive emphasis on its technological functions which is now prevalent. Most of those who chose a scientific career at any stage of their education would no doubt enter one of the great fields of the application of science to human use, both because the volume of employment in the technological field is and will continue to be much more ample, and because the qualities required in many such posts are much commoner than those necessary for the successful pursuit of pure research.

A comparatively small minority would engage in research or in teaching combined with research, as they do now, but this minority would be powerfully reinforced, in quality as well as in quantity, by drawing on hitherto untapped resources of the population. Comparatively rare as the combination of marked ability and strong inclination for research in pure science may be, there can be no doubt that it exists in many who at present have no opportunity of following their proper bent. The liberal school education I am contemplating should help to free the minds of those who follow any kind of scientific career from the distressing and harmful narrowness some of them now display. At the same time the acquirement of some knowledge of the real nature and significance of science should also help to abolish the equally distressing and harmful dislike and distrust of science among others to whom I have alluded.

Science is part, and by no means the least important part, of our cultural heritage, though it cannot, of course, satisfy the whole range of man's spiritual demands. We are often told that science alone is not enough, that its essentially mechanistic analysis of phenomena, not only the phenomena of the external world but of the mind itself as they are revealed by modern psychology, does not touch the essence of the human soul and cannot explain the highest values of which we are conscious. That I freely admit. Certainly we cannot do without literature, art and music, nor can we dispense with religion in its widest sense. What I assert is that science, too, makes its own contribution to spiritual values, and that to limit its function to the material sphere is to impoverish our culture most disastrously.

The recent movement which exalts the material function of science and denies the right of pure science to an independent existence is a kind of philistinism which plays into the hands of those who dislike and distrust science and are only willing to concede its material services. One of the leaders of this movement tries to bolster up his case by rather childish misrepresentations of the motives of scientific research, suggesting that scientific curiosity is "not particularly noble", that the joy of new discovery, the delight in establishing some new fragment of objective truth, of contributing, in however small a degree, to a clearer insight into the order of Nature, are not the dominant impulses and feelings of the worker in pure science, that he is more often actuated by a desire to rise in the world, and that he will gladly turn his back on research to become an administrator. Such contentions are flatly contradicted by the experience of those actually engaged in research, who have the best opportunity of observing the dispositions and behaviour of their fellow-workers. That many scientists do in fact turn to administrative work in their later years is perfectly true. The ardent curiosity of the true investigator and his capacity to continue the strenuous though delightful mental work involved in continuous research often weaken as the mind loses its early vigour, though some minds retain them throughout mature life. Nor can we assert that the attractions of an easier life and a larger income are negligible, especially to those who are conscious of the weakening of their earlier impulses. But the existence and effectiveness of these other motives in such cases do not affect the truth that the actual motives of pure research are highly characteristic and remarkably strong and pure. The evidence is plain to all who will look at the facts, unless they wish to believe the contrary.

The main contention of this school of thought is, as we have seen, that research in science is always governed, consciously or unconsciously, by current social needs, and that we should now deliberately organize or 'plan' all research with the immediate object of continuing to satisfy those needs. That 'planning' must play a very large part in our future social and economic life I should be the last to deny. It is equally true that most technological work must be planned and that even in the realm of pure science there are problems that can only be dealt with effectively by directed teams of workers. This applies particularly though not exclusively to much exploratory work and to preliminary surveys of wide scope. But the highest type of research, that which has been productive of the most fundamental discoveries, is essentially the work of individual minds, freely dealing with their own chosen material. That is the evidence of the whole history of science. If we desire to keep alive and vigorous the ultimate springs of our material welfare, and—not less important—to maintain and extend the place of science in our culture, we must jealously guard its freedom and its independence.

PORTABLE MASS SPECTROMETER

By JOHN A. HIPPLE, jun.
Westinghouse Electric and Manufacturing Co., East Pittsburgh

THE mass spectrometer illustrated below was developed at the Westinghouse Research Laboratory in East Pittsburgh as a tool for some routine gas analysis problems. A rather complicated mass spectrometer had been used for this work; experience with this apparatus indicated that it would be desirable to have a compact, self-contained unit that could be moved to the position where a gas analysis was desired. The result of this was the development of the present instrument.

In contrast to the Aston type of high-precision instrument, high resolution is not so important here as high sensitivity and ease of measuring quantitatively the amount of ion current. For this reason the current is measured electrically. This mass spectrometer uses the focusing properties of a magnetic field described by Barber[1] and Stephens and Hughes[2,3]. Instruments using this principle have usually used a magnetic deflexion of 60°. Examples of this are the instruments of Bainbridge and Jordan[4] and Nier[5]. As is evident from Fig. 1, a deflexion of 90° has been used in the instrument here described. In the figure, the magnet has been withdrawn from its operating position to permit a better view of the tube itself. The 90° deflexion has been used for compactness, decrease in the ion path-length and simplicity of alignment and operation. The vacuum envelope is made entirely of glass and the electrodes are made of 'nichrome'. The tube is made in a jig and, when it is removed from the jig, no further alignment is necessary. The ions are shielded from the glass in the analyser region by means of a flexible 'nichrome' shield which fits inside the glass tube. The slits are of the order of 0·020 in. and the radius of curvature of the ions in the magnetic field is 5·0 in. With this geometry, the resolving power is about one mass unit in one hundred.

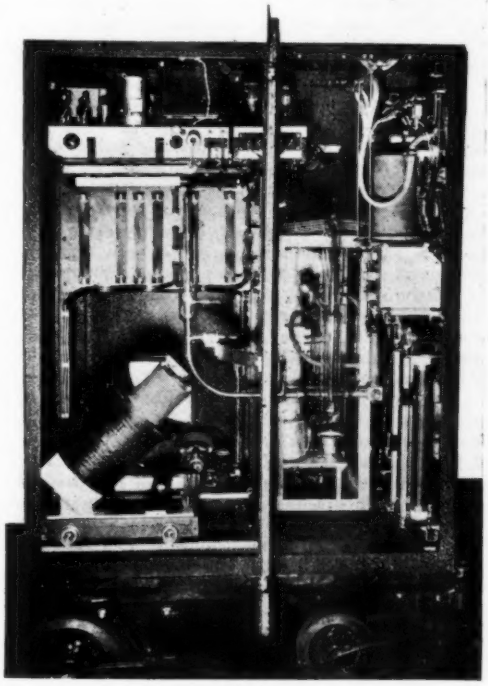


Fig. 1.

Fig. 2.

The magnet coils are wound with many turns of fine wire so that the maximum field is obtained with a voltage of 800 volts and a current of 0·100 amp. The power supply is an electronically stabilized rectifier shown at the top of Fig. 1. This 1,000-volt power supply also provides the accelerating voltage for the ions. Since the ion-accelerating voltage and the magnet voltage are provided by the same supply, an additional regulation is obtained as well as an economy in design.

The pumping system consists of two glass mercury diffusion pumps backed by a mechanical forepump. The diffusion pumps and the gas handling system for admitting the gas to the mass spectrometer are mounted on a sub-assembly which can be removed from the main assembly in a few minutes.

The ion current is measured in a conventional way by means of a sensitive electronic current meter. This instrument is mounted in an evacuated housing with sensitivity adjustment by a control on the front panel. The power for this instrument is provided by an A.C.-operated direct-current supply which is electronically stabilized. Another stabilized source provides the voltage for the electrons in the ionization chamber.

The entire apparatus is enclosed by a frame with steel panels except the front which is 'Micarta'. All sides and the top of the enclosure are provided with either hinged doors or panels which snap into position

and are easily removable. In this way, there is ready access to all parts of the instrument. Fig. 1 is a view showing the side open, while Fig. 2 illustrates the complete unit ready for operation. It will be noted that the entire assembly is mounted on a truck for easy movement to any part of the building. Since the mass spectrometer is operated completely by alternating current, the only connexions to be made when the unit is in place is one to the A.C. voltage supply and water connexions for cooling the diffusion pumps.

In addition to the features of compactness, ease of operation and portability, the design permits ready shipment from one place to another, since all the component units may be removed in a short time from the main assembly. As an illustration, the first apparatus of this design was sent from Pittsburgh to New York (400 miles), operated in New York for a week and then returned to Pittsburgh without mishap and with very little trouble.

[1] Barber, *Proc. Leeds Phil. Soc.*, **2**, 427 (1933).
[2] Stephens and Hughes, *Phys. Rev.*, **45**, 123 (1934).
[3] Stephens, *Phys. Rev.*, **45**, 513 (1934).
[4] Bainbridge and Jordan, *Phys. Rev.*, **50**, 282 (1936).
[5] Nier, *Rev. Sci. Inst.*, **11**, 212 (1940).

CARE OF WORKS OF ART IN WAR-TIME

By F. IAN G. RAWLINS

BY 'care' in normal times is probably understood due conservation and maintenance; this in fact is the elemental work which devolves upon curators of any collection of works of art. In times like the present, however, two novel aspects appear: one is protection against enemy action, and the other—a kind of dependent variable—is the greatly increased difficulty of ensuring proper care (in the usual sense) which the necessity for such protection tends to bring about. In other words, there is a distinct possibility of devising excellent 'cover' but at the same time exposing the treasures to such risks of damage and deterioration by inadequate transport and storage arrangements, that the verdict of posterity may well be, "If only they had been left where they were. . . ."

This is not merely to seek a nice balance in policy: sooner or later—perhaps sooner—a decision will have become vital; and if, as this article assumes, the plan amounts in effect to evacuation, then it is not a matter to be taken lightly. The hazards may indeed be severe. However, it is by no means my intention to make too much of them. Many can be overcome, and have in fact been overcome. But they are always there, and for the most part, experience to cope with them is not very extensive.

Clearly, evacuation is unjustifiable unless it is reasonably certain that the sum total of the chances of destruction (not only those due to hostilities) is thereby definitely reduced. There are, broadly, two alternatives: (1) dispersal, (2) deep shelters, for example, quarries, tunnels and so forth. The former amounts in practice to the use of country houses as repositories, sending a comparatively small number of objects to each; the latter is more drastic and will probably end in putting the whole collection underground in one place. Which of these methods is chosen will naturally depend upon considerations outside the scope of this contribution. The intention now is to discuss ways and means of securing a tolerable exile.

Dispersal

Technically, private houses, public halls and buildings of that category present a number of complexities, which make it most important to examine them in detail beforehand. For example, the flooding of basements (otherwise promising storages) is sometimes to be apprehended. The fire risk is usually considerable; appliances will almost certainly need augmenting. Moreover, for books and pictures especially, if the only way of dealing with an outbreak is by water, the curator may even be well advised to avoid the scheme altogether, since the damage suffered would probably be almost irreparable. Generally, the only effective safeguard is to have staff always available for instant salvage in case of fire. This implies the availability of a spare 'sanctuary'. The possible presence of dry-rot in timber floors should not be overlooked. In many instances woodwork can be adequately protected in occupied premises against mould growth and from becoming infested by bacteria by the application of a 10 per cent solution of copper naphthenate in paraffin. Fireproof paint or solution should be applied where desirable, both to wood and to any hangings or curtains used to exclude draughts or to form parts of air-locks. The majority of precious objects are most unlikely to be injured by war gases in vapour form. Splashes of the liquid, however, are almost sure to be fatal on books, manuscripts, pictures and textiles. 'Cellophane', oilskins, rubber fabrics, decreasing in effectiveness in that order, form reasonably sound protective coverings.

The most important factors of all are likely to be temperature and relative humidity (R.H.). It is usually considered that most museum materials and exhibits are well provided for at a temperature of 60° F. and 60 per cent relative R.H. Research on this subject is as yet insufficient to enable exact figures to be stated, but there is some reason to suspect that the traditional values of 60° F. and 60 per cent R.H. have been accepted more on account of the comfort of visitors to galleries than on behalf of the contents. While temperature *per se* is not of the greatest moment, relative humidity assuredly is. It seems likely that a range of between 50 and 55 per cent at around 60° F. is nearly ideal. Fluctuations in relative humidity such as commonly occur in most buildings at certain seasons of the year are most undesirable. They may produce strains leading to complete breakdown in some pictures (panels in particular), and to a lesser extent with other objects.

The control of relative humidity in war-time storages is exceedingly difficult; so much so indeed as to constitute a major problem. Obviously, fairly simple measures, capable of being implemented more or less on the spot, are all that can be reasonably expected. The main question is how to combine adequate ventilation with satisfactory constancy of relative humidity without elaborate machinery. It is easy enough to install some electric (preferably tubular) heating in a store room, and even to maintain an approximately level temperature, piercing doors or partitions to gain free air-circulation. But it will usually be found that the relative humidity varies over very wide limits, simply repeating the day and night changes that occur outside. The

range may well be between 40 and 70 per cent or more. These are definitely dangerous limits.

In my experience there is only one course to adopt, and that to some degree at variance with customary methods. It is to seal off the storage chamber as effectively as possible from external influences, by stopping up doors, windows and cracks, and by hanging up heavy felt or similar material. Then small electric fans can be used, suitably orientated, to stir up the air inside the storage chamber itself. Fresh air can, of course, be admitted, when weather conditions are favourable, for a short time. Given reasonable heating, the relative humidity should be roughly constant. That is one point gained. If it settles down to a figure unduly high, say above 65 per cent (see later for the significance of this) more well-dried fabric may be introduced, or the temperature raised, so long as it does not in general exceed 70° F. If the relative humidity is too low, the temperature may be lowered a little, and wetted material suspended. It is probably prudent to avoid chemical drying agents like calcium chloride or phosphorus pentoxide in the same room as valuable objects. It will doubtless be noticed that the more hygroscopic material there is in the chamber the less sensitive does it become to abrupt changes of relative humidity.

Wherein this treatment differs from that commonly envisaged is its insistence upon constancy of relative humidity even at the expense of 'proper' ventilation. Naturally, if reasonable freedom from fluctuations in relative humidity can be obtained with air-flow from outside, so much the better; it appears, however, to be a most unlikely state of affairs to find (or even to attain) in war-time quarters.

Instrumentation may well be on a simple scale. Thermostats can be efficient for temperature control, but some method of testing the relative humidity regularly is essential. A psychrometer, or whirling hygrometer, is the obvious way, though recording instruments are useful adjuncts if periodically checked. At least they show the general trend.

Deep Shelters

These are inevitably in the nature of a long-term policy, and probably out of the question for the majority of institutions and private owners. Nevertheless, they are of great importance, and of considerable scientific interest. Clearly, no perishable material of value can be stored in quarries, caves, tunnels and such-like places without elaborate preparations on the site. The chief enemy is damp; the fire-risk, on the other hand, should be diminished compared with that for isolated houses. Other hazards, less obvious perhaps but sometimes no less severe on that account, are flooding, noxious vapours and gases, dust and falls of roof. These points are excluded from further discussion, since any proposed underground repository where such dangers exist would naturally be rejected out of hand.

We are left, therefore, with the ever-present problem of temperature and humidity control. One favourable factor may be expected to appear immediately, namely, that in many subterranean workings the temperature is approximately constant throughout the year; but the relative humidity may be high—around 90 per cent—and fairly even. Thus, it will be necessary either to erect buildings inside, or to block off suitable portions of the space and to 'condition' them as effectively as may be needed. Which method is adopted will depend largely upon the type of rock strata involved, and to some extent upon the shape and general lay-out of the place. The class of material to be stored will also weigh. If the natural temperature is low enough (around 45° F.), it may be possible to obtain the relative humidity required, say, 55 per cent at 60° F., by straightforward temperature control alone, without recourse to refrigeration, except perhaps temporarily, to hasten the process of drying out. If this is so, and electric power is available, as it supposedly would be in many cases—the project becomes quite tractable. In fact, conditions approaching the ideal can be realized relatively simply, given sound initial equipment and constant supervision. A stand-by generating plant in case of power failure is, of course, essential.

Repositories of this kind represent a type of scheme 'easier said than done', however; difficulties of a somewhat crude nature are apt to appear very early in the proceedings. One is often that of access, both to the site itself and to portions of it below ground which theoretically are the most advantageous to occupy. It should always be borne in mind that priceless and irreplaceable things are to be brought there (since such a plan would never be contemplated for minor exhibits), unloaded and perhaps unpacked, put in place and duly invigilated. In addition to which it may be necessary to allow for objects of great bulk combined with excessive fragility—altogether not an enterprise to be embarked upon too lightheartedly. A good feature awaiting us, however, is that quarry—and some other—adits are often far from straight, which is a great advantage in forming natural baffles against the propagation of blast.

General

There remain a few general considerations common to any programme of evacuation and war-time storage of valuables and perishable objects. One is that of avoiding the growth of mould or mildew. A relative humidity so low as 68 per cent has been found to permit of mould growth, especially at temperatures around 70° F., showing that raising the temperature is not in itself any security, if the relative humidity remains excessive. Good ventilation, or at least adequate air-movement, is a safeguard. Another matter concerns lighting. Some illumination is desirable as a check upon mould growth itself. In addition, for pictures less than about fifty years old, there is a tendency for the medium to turn yellow, especially if of a 'fat' nature. This process is favoured by darkness. For older paintings, oxidation is probably complete, and no colour change need be expected as the result of storage away from light, so far as the medium is concerned. Water colours and miniatures should always be stored away from light. Where possible, objects should be unpacked to facilitate inspection, and to give the best chance of air circulation.

Generally, there can scarcely be hard and fast rules, except perhaps to recollect that flooding, exposure to excessive relative humidity, attacks of mildew and—no less—inadequate or rough transport may bring about damage amounting almost to disaster. None of these things should stand in the way of seeking the safest place for works of art. But 'watch and ward' was never more urgent.

Some scattered literature on the subject began to accumulate as the result of the Spanish Civil War.

Since then two valuable contributions have appeared: (1) "Air-Raid Precautions in Museums, Picture Galleries and Libraries" (British Museum Trustees, 1939) and (2) "Preservation of Paintings in War-Time" by G. L. Stout (Fogg Art Museum, Harvard University, U.S.A., 1942). Meanwhile, data are being assembled from day to day as the result of experience in war-time repositories. Much of it would never have been obtained in years of peace. Some of it will doubtless be significant for future planning of museums and galleries.

OBITUARIES

Sir Daniel Hall, K.C.B., F.R.S.

SIR DANIEL HALL—long known simply as A. D. Hall—had an unusually wide circle of friends who will deeply mourn his death on July 5 at a nursing home in London.

He was born at Rochdale on June 22, 1864, and was educated at the Manchester Grammar School, where he already showed wide scientific interests and was equally keen on chemistry, physics and the field sciences, botany and geology. From Manchester he gained the Brackenbury Science Scholarship to Oxford and entered Balliol College in 1881. Here he was soon recognized as possessing entirely exceptional qualities and he lived a very full life. At no time was he a narrow specialist, least of all during these formative years at Oxford. Everything he touched he did well, whether it were science, athletics, or participation in the various movements then forming part of Oxford life. He rowed in the Balliol eight and he laid the foundations for those wide intellectual and artistic tastes which characterized him throughout his life and added so much to his personal charm. At Oxford, too, he was fortunate in his choice of friends, many of whom afterwards had distinguished careers. He did not remain at Oxford, but left in 1884 to become a science master at King Edward VI Grammar School, Birmingham, where he met his first wife, Mary Brookes, and wrote his first book, a little text-book for the use of his students. He soon gave up school teaching and for a time served as lecturer in the university extension movement then beginning; Kent and Surrey were his counties; they were then more rural than now. Here he became interested in agricultural education and he soon saw that if it was to be effective it must be systematic and continuous; occasional lectures were quite inadequate. He was able to persuade a very public-spirited gentleman, E. J. Halsey, of the soundness of his views, and Mr. Halsey saw that funds were provided for establishing an agricultural college. Hall knew the two counties well, and selected the old Latin school at Wye as the proper place; it was a medieval foundation with attractive old buildings that gave the setting he always liked so much. He took possession in 1894 and was able to add laboratories and new buildings without doing violence to the old ones.

Hall was ably supported by a group of able men: F. B. Smith, J. Percival, F. Theobald, T. R. Robinson and H. H. Cousins, and between them they worked out systematic courses on agricultural science and practice, and trained numbers of young men who afterwards held very important posts at home and abroad. Hall insisted that the teaching must not only be based on sound science but must also constitute a new science, always drawing on practical agriculture for its materials and its illustrations. He set the example by becoming a first-class grower of fruit, hops and flowers, especially roses, tulips and sweet peas; he could hold his own with any expert, and the farmers and gardeners of Kent quickly recognized him as a fellow-craftsman of outstanding distinction. He was equally successful in dealing with farmers; he was a remarkably shrewd observer and could quickly detect the flaw in management which had led to some unsatisfactory condition of crops or animals. The early prejudice against agricultural education could not stand up against ability of this sort, and before long the high position of Wye was assured.

Hall always recognized, however, that both the teaching and the advisory work then beginning to develop were limited by the amount and value of the science on which they were based, and very soon this began to be insufficient. There was at that time no provision for research; education was supposed by the administration to be a proper object for State aid, but not research, which was regarded as something entirely distinct and unrelated. Hall set himself to remedy this defect; he gave up Wye at the height of its success and in 1902 went to Rothamsted in succession to Gilbert; he found the whole place moribund, but with characteristic energy and devotion proceeded to put new life into it. He had neither staff, apparatus nor funds and was snubbed by the Board of Agriculture when he asked for a grant, yet his infectious enthusiasm attracted first men then money, until finally he had built up a compact team of research workers who opened lines of investigation that have since proved very fruitful. The Goldsmiths Company gave a handsome endowment for soil research and this lead has been followed by a long line of generous supporters.

Once again, however, Hall felt impelled to give up the work when he had got it well on the road to success. In 1909 Mr. Lloyd George set up the Development Fund for the purpose of developing agriculture and improving rural life, and he appointed a small Commission, including Hall, to administer it. Hall soon became the dominating figure and in October 1912 was induced to give up Rothamsted so as to devote his whole time and energy to the work. The full story has not yet been written, and reference can be made here only to that part dealing with research and education. It was agreed that agricultural research was to be greatly developed. Two methods were possible: the establishment of a large central research station covering all branches of agriculture on the model of the United States Department of Agriculture at Washington; or a number of smaller stations attached to the universities, where different branches of agriculture or agricultural science would be studied. The latter method was chosen, and there is no question that the decision was sound. Agricultural science has developed remarkably well in Great Britain as the result of the freedom conferred by the new arrangements, which were indeed the envy of scientific workers from other countries when they came over here. A very effective advisory service was also set up and the educational machine was greatly improved. Later experience has shown that these three services could well have been more closely linked, but there is no evidence that Hall was responsible for that defect. He certainly achieved a great amount of most useful constructive work.

Then in the War of 1914–18 came another change; at the crisis in 1917, when 'total war' was forced upon us and all peaceful activities had to be abandoned, Hall gave up the Development Commission and became Permanent Secretary to the Board of Agriculture under his old friend Prothero (afterwards Lord Ernle) as Minister. Here he was less happy than in his previous posts; he gave the impression that he found office routine very irksome; all his life he had been accustomed to prompt decision and speedy action, and in any event the times were unpropitious. When Bateson died in 1926 Hall accepted the directorship of the John Innes Horticultural Institution at Merton, retaining only a part-time connexion with the Ministry of Agriculture as its scientific adviser. Once more he was back in the atmosphere he loved; his coming, Darlington said, was like a breath of fresh air; and he rounded off a life-time of experience and observation of tulips and apples by producing two monographs which are not likely to be superseded in our time. He stayed on until 1939 and then retired, but only to change his occupation. He had always been interested in the Lord Wandsworth Agricultural School at Wantage, and as chairman of the governors he went to live there so that he might keep closer touch with its activities.

Few men can have lived a fuller life or one more helpful to the community. His influence will last long after our time, and the beneficial activities he started will go on bearing fruit, while his memory will be an abiding inspiration to all who had worked with him.

E. J. RUSSELL.

Prof. D. la Cour

PROF. DAN LA COUR, director of the Meteorological Institute of Denmark, died at Copenhagen on May 19 at the age of sixty-five; his death will be deeply regretted by geophysicists throughout the world. During the past fifteen years or more he took an increasing part in international leadership in geophysics, the science for which above all others international co-operation is essential; at the time of his death he was president of the International Union for Geodesy and Geophysics. He was elected to this office at Edinburgh in 1936, and would normally have vacated it in 1939, but at the Washington conference of the Union, held just after the outbreak of the present War, new elections of officers were postponed; his advice and guidance in re-starting the work of the Union when peace returns will be greatly missed.

Prof. la Cour was born at Copenhagen on September 12, 1876, of a family of high distinction in Denmark; his father was a High School physics master. After completing his university studies at Copenhagen, he became an assistant of the Meteorological Institute in 1900, under the directorship of van Ryd; in the year previous to this he took part in a Danish auroral expedition, and during 1900 he was leader of this expedition. From 1903 onwards he took charge of the Department of Weather Services, and from 1920 also of the Magnetic Department. In 1923 he became director of the Institute. From 1908 onwards he lectured on meteorology at the famous Copenhagen Polytechnic Institute. In 1927 he was elected to the Danish Academy of Sciences, and in 1939 to the Danish Academy of Technical Science. He received also many honours from other countries, and held numerous important offices in international scientific bodies.

Among the services la Cour rendered to the advancement of geophysical observation, one of the greatest was connected with the plans for the repetition, in 1932–33, of the International Polar Year of 1882–83, when the leading nations co-operated in sending expeditions to various parts of the north polar regions, in order to make meteorological, magnetic, auroral and other observations throughout a whole year. The project for a renewal and extension of this work, with modern instruments and methods, in the jubilee of the original polar year, was mooted in good time for new expeditions to be planned, and in 1928 the International Meteorological Committee appointed a commission to organize the work. In 1931, however, the world economic crisis deepened, and there was danger of the project being abandoned; la Cour was foremost in withstanding this, and under his leadership, as president of the International Polar Year Commission, the great enterprise was carried through to success.

In facilitating afterwards the use of the large mass of new data thus obtained, la Cour likewise played an important part, with the enlightened generous support of the Danish Government. An international bureau was set up in his Institute, and there he organized the reproduction, on micro-films, of the magnetic and some other data. In this and his other work he and the skilled staff he gathered around him achieved first-rate results with great economy of money and effort.

He extended the scope of Danish observations in geomagnetism by establishing (in 1927) a permanent magnetic observatory at Godhavn, in Greenland (only 10° from the pole of the earth's magnetic axis), in addition to the long-existing Copenhagen observatory (now at Rude Skov). He also started a new series of Danish geomagnetic publications ("Communications Magnétiques") to supplement the Danish magnetic observatory yearbooks.

La Cour also aided geomagnetic science very greatly by his many improvements in the design of magnetic instruments, through which the accuracy and reliability of magnetic observations and records were notably raised. He overcame several inveterate difficulties that long hindered the attainment of the high degree of precision aimed at in geomagnetic measurements. One such difficulty was connected with the use of fine quartz suspension fibres. The usual clamping of their ends did not prevent slipping, and injured the fibres: la Cour, who was himself an adept in their manipulation, left a quartz drop at each end of the fibre, and placed each drop in a simple mounting of special design; subsequent light heating fused the quartz and provided a safe connexion with the holder. Again, the magnetic balance, for the continuous measurement of the vertical magnetic force, is exceptionally sensitive to slight changes in the position of the magnet relative to the knife edges on which it is balanced; la Cour avoided any such displacements by making the magnet, knife-edge and mirror in one piece, of tungsten steel, weighing in all only 2·5 gm. He also introduced a simple, ingenious and satisfactory method of optical temperature compensation for magnetic recorders. His improvements probably have valuable applications in other branches of observational and experimental physics. Only a few of his instruments and devices are mentioned here; a paper describing the latest of his instruments, for the measurement of the vertical magnetic force, reached England only a few days ago.

La Cour did much by example, precept and international intercourse to promote the improvement and extension of magnetic observations, and the intercomparison of magnetic standards. I was privileged in 1936 to accompany him on a tour with this object, to magnetic observatories and institutes in Sweden, Finland and Russia; he was a most kind, courteous and agreeable companion.

He was a tremendous worker, and was remarkable also for his capacity to inspire others with the same ardour, to an extent that perhaps sometimes surprised even themselves. His manner and his dignified movements suggested calm, irresistible strength.

La Cour was married and had one son and four daughters, who with Mrs. la Cour survive him. On his international journeys he was often accompanied by one or more members of his family, and in consequence there are many countries in which a personal sympathy with his family will be felt in their and our loss. S. CHAPMAN.

WE regret to announce the following deaths:

Prof. J. C. Arthur, emeritus professor of botany since 1915 at Purdue University, and president in 1902 and 1919 of the Botanical Society of America, known for his work on the plant rusts, on April 30, aged ninety-two.

Mr. F. C. Baker, curator emeritus of the Museum of Natural History of the University of Illinois, corresponding member of the Zoological Society of London, on May 7, at the age of seventy-four years.

Dr. G. B. Batten, a pioneer of X-ray treatment, who was president during 1918 of the Röntgen Society, on July 9, aged eighty-one.

Dr. Charles R. Keyes, consulting mining engineer, founder and editor of the *Pan-American Geologist*, on May 18, aged seventy-seven.

Dr. M. W. Lyon, jun., pathologist of the Clinic, South Bend, Indiana, and president during 1931–33 of the American Society of Mammologists, on May 19, aged sixty-seven.

NEWS and VIEWS

Charles Blacker Vignoles and the Royal Society

AT a meeting of the Royal Society on July 16, a gold snuff-box, once the property of Charles Blacker Vignoles, F.R.S. (1793–1875), was presented to the Society by his grandsons, Mr. E. B. Vignoles and Lieut.-Colonel W. A. Vignoles. Mr. Vignoles, in making the presentation, referred to the fact that in 1841 C. B. Vignoles presented to the Royal Society a fine portrait of Sir Isaac Newton, which had come to him as the result of a connexion between his mother's family and that of Sir Isaac. Mr. Vignoles said that his grandfather, who was of Huguenot descent, came of a long line of soldiers and was an orphan and a prisoner in French hands at the age of thirteen months. He was educated by his maternal grandfather, Dr. Charles Hutton, F.R.S., the mathematician, the author of "Hutton's Logarithms", in the preparation of which Vignoles assisted. As a young man he served for a time in the Army, taking part in the disastrous attack on Bergen-op-Zoom in 1814. Following the peace after Waterloo, he went to America, where he was engaged on survey work in South Carolina and Florida, then very little known. Returning to England in 1823 he was soon engaged in railway engineering, almost his first work being the first survey for the proposed Liverpool and Manchester Railway. In the course of a long career he carried out important work at home and abroad as a railway and civil engineer, including the great suspension bridge over the Dnieper at Kieff and a railway through the Cantabrian Pyrenees from Bilbao to Tudela, which with its sharp curves and bold moving of a river, struck a new note in railway engineering. The 'Vignoles rail', the flat-bottomed rail of his design still used all over the world, keeps his name familiar to railway engineers. Vignoles was elected a fellow of the Royal Society in 1855 and was president of the Institution of Civil Engineers in 1870–71.

The snuff-box, now presented to the Royal Society, was given to Vignoles by the King of Württemburg, in 1844, as a mark of his esteem, after Vignoles had advised the King on plans for the railways of the State. The snuff-box is of solid gold with a portrait of the King set in diamonds on the lid; inside the lid is an inscription in French giving the circumstances of the presentation and signed by Goes, Secretary of State of Württemburg.

Social Medicine at Oxford

THE Nuffield Provincial Hospitals Trust, with the approval of Lord Nuffield, is to devote £10,000 a year for ten years to the creation in the University of Oxford of a University professorship of social medicine, and the foundation of an institute in which the professor will work. The purposes of the institute are: "To investigate the influence of social, genetic, environmental, and domestic factors on the incidence of human disease and disability. To seek and promote measures, other than those usually employed in the practice of remedial medicine, for the protection of the individual and of the community against such forces as interfere with the full development and maintenance of man's mental and physical capacity. If required by the university to do so, to make provision in the institute for the instruction in Social Medicine of students and practitioners of medicine approved by the Board of the Faculty of Medicine in the University of Oxford."

Scientific Men in War-time

A DEPUTATION arranged by the Parliamentary and Scientific Committee saw Mr. R. A. Butler, president of the Board of Education and chairman of the War Cabinet Scientific Advisory Committee, who was accompanied by Prof. A. V. Hill, on July 16, to urge the Government to set up a full-time scientific and technical joint board. This would have as its aim the fullest strategic use of scientific man-power and resources and the proper organization and exchange of scientific and technical information relating to the war effort. The deputation included Lord Hinchingbrooke, Lord Leverhulme, Lord Pentland, Lord Samuel, Sir Lawrence Bragg, Capt. L. Plugge, Prof. B. W. Holman, Dr. W. Wooldridge, Mr. J. H. Wootton-Davies, and representatives of the British Association of Chemists, Institute of Physics, Institute of Struc-

tural Engineers, Association of Scientific Workers, Institution of Mechanical Engineers and the Institute of Chemistry. The deputation clearly had as its object the views expressed in the leading article in NATURE of July 18.

Statistical ('Quality') Control of Production

SIR CHARLES DARWIN, director of the National Physical Laboratory, was the principal guest at the July meeting of the Scientific Instrument Manufacturers' Association of Great Britain, and spoke after luncheon about the use of statistical methods in the control of machine-production. He described some developments of these methods in mass-production in the United States; and the encouraging practical outcome of the discussion on the subject in April held at the Institution of Mechanical Engineers (see NATURE, May 23, p. 573). 'Quality control', as contrasted with simple 'limit' gauging (go or not-go) and the rigid specification of tolerances, applies the principles of the law of errors towards obtaining advance information of the tendencies in course of machine production, and towards correlating the users' requirements with manufacturing economy. Sir Charles gave impressive illustrations of practical results following adoption of this method.

Makers of scientific instruments are not ordinarily affected by considerations introduced by mass production methods; and there was some tendency to question the applicability of statistical method to quantities such as they usually handle. There was, however, considerable interest in its possibilities in regard to the quantities in which they are now making many military instruments. Several speakers attached much importance to letting the operatives see their working charts, describing the stimulus value of bringing home to the workers the results of the work they are doing. There was a suggestion that the service inspection departments stand in greater need of education in statistical principles than do the manufacturers; but the speaker was reassuring about official sympathy in this direction.

British and Russian Naturalists

THE following telegram was received by the Linnean Society of London from the Moscow Naturalists' Society on July 11: "Linnean Society, London. Council of Moscow Naturalists of which Charles Darwin was honorary member has been instructed by its members assembled at meeting in commemoration of centenary of appearance of his Origin of Species to convey their ardent greetings to Linnean Society. In midst this great ordeal which has fallen to lot of democratic countries and of science Moscow Naturalists' Society oldest scientific society in Soviet Union pays reverent tribute to memory great scientist and humanist and firmly believes in early victory of our countries over Hitler tyranny". Academician Alexander Fersman, Professor Serge Ogneff, Professor Vera Varsanofieva (vice-presidents), Professor Serge Lipshitz (Secretary).

The following telegram was sent by the Linnean Society of London in reply on July 16: "Moscow Naturalists' Society, Moscow. The Linnean Society of London heartily reciprocates your friendly greetings and joins in tribute to memory of Charles Darwin most illustrious member on our roll. The magnificent resistance of the Russian people to Nazi aggression has aroused deepest admiration in our country. We share your confidence in early victory of the United Nations and are with you to the end". E. S. Russell (President).

Polish Science and Learning

ATROCITY follows atrocity so rapidly on the continent of Europe that public conscience is only momentarily aroused by any fresh crime made in the name of the Nazi 'New Order' in Europe. The Polish nation has been the special object of German fury, and Polish scholars and men of science in exile feel it is their duty to remind others of what is at stake. *Polish Science and Learning*, which resembles *Nauka Polska* (Polish Science) that recorded during 1919–39 the trends and progress of general and natural science, has been founded by a group of Polish savants now working in Great Britain and representing seventeen universities, academies and research institutes. Its object is to record the continuation of their researches as well as to direct attention to events in their unhappy country, where all universities and colleges and indeed all educational establishments above primary schools have been closed. Of the hundreds of periodicals covering all branches of pure and applied science, not one is left. Practically the whole of the rich Polish literature is denied to the nation to-day. In 1940 the Germans issued a 49-page list of books banned from all libraries in Poland. It included the names of 1,500 authors and the number of works cited was about five thousand. Meanwhile, Polish university life is being maintained in Britain and the United States. Many professors and lecturers are carrying on researches at British universities and institutions, and an imposing list of publications has already resulted. In addition, a complete Polish Medical School was established at Edinburgh in 1941. Also, an autonomous Polish Institute of Science and Learning has been set up in New York to act as a publication centre and to arrange courses of lectures and discussions. There is thus a continuity of Polish scientific work, and a body of savants is ready to resume duties at home when their land is liberated.

Cotton Research in East Africa

THE report of the administrative council of the Empire Cotton Growing Corporation submitted to the twenty-first annual general meeting on June 2 refers to a report by the Scientific Advisory Committee which outlines a scheme for the establishment by the Corporation of a Central Cotton Research Station in Uganda. Careful examination of the work being done by the present experiment stations has confirmed the view expressed in last year's report as to the value for the Empire of such a station in East Africa, at which fundamental scientific investigations could be carried out arising from practical problems that confront cotton-growing in those Dominions and Colonies in which the crop is cultivated on a commercial scale. The functions of such a station are defined as to carry out research on problems of cotton growing, especially on those of common interest to several territories. Such work should have a practical bearing on cotton production, and cotton should be treated as an element in peasant agriculture, compatible with food production, the prevention of erosion and the maintenance of soil fertility. Its functions would also include the co-ordination of certain activities of the Corporation's stations elsewhere in Africa, and if requested, of stations working

on cotton and staffed by the Colonial Agricultural Service.

Though no distinction should be drawn between fundamental and immediate research work, an orderly division should be made between general and local problems, the former being incorporated in the programme of the research station and the latter suggested for investigation at other stations. The research station should collaborate with the latter in the particular application of general results to local conditions, and its work should also be framed so as to be complementary to that of the Departments of Agriculture. The Corporation hopes to be able to provide the finance necessary for the recurrent expenditure of the research station, and the Colonial Office has been asked to approve in principle a grant being made after the War from the Colonial Research Fund to cover the capital cost of the station in land, buildings and equipment. The report of the Council also includes some notes on the work during the year of the Genetics Department and the Physiology Department of the Research Station, Trinidad, and on research work carried out at the Universities of Cambridge and Manchester, the Imperial College of Science and Technology, and the Rothamsted Experimental Station.

Folk-lore Treatment of Sneezing

THE March issue of the *Bulletin of the History of Medicine* contains an interesting article on contemporary folk-lore treatment of sneezing by Dr. Leo Kanner of Baltimore, who classifies the folk-lore remedies for this condition in the following categories: (1) suggestions, general or specific, of the healers whom the patient should consult; (2) metaphysical cures and prayers, mental equilibrium and magnetic treatment; (3) cure through fright; (4) external remedies, such as pressing and rubbing; (5) local applications to the nasal mucous membrane; (6) spraying, inhaling, snuffling, smelling and gargling; (7) exhaling; (8) remedies *per os*; (9) complicated recipes; and (10) hygienic and dietetic measures. Dr. Kanner comes to the conclusion that contemporary folk-lore, despite its apparent simplicity, is a highly complex mixture of a number of different ingredients which consist of the retention of beliefs and practices dating back from the earliest times; borrowed but not fully understood gleanings from current scientific medicine; survival of methods which were part of the repertory of practitioners two or three generations ago; and references to present-day healing cults.

Prophylaxis of Malaria in Argentina

IN a recent paper (*Bol. Of. San. Panamericana*, 21, 233; 1942) Dr. Hugo J. D'Amato, secretary of the National Department of Hygiene at Buenos Aires, states that during 1940, and especially from January until April, there was a decided increase in the number of cases of malaria in North Argentina, where the disease is endemic, with the exception of those areas protected by the public health services, thus proving the efficiency of the methods applied. More than 170,000 patients were examined by the services of the National Department of Health and more than 20,000 in the provincial and municipal institutions; this is an increase of 5 per cent on the figures of the previous year. *P. falciparum* accounted for 33 per cent of the infections as compared with 12 per cent for the previous year. In 1940, 11,200 more patients were treated than in 1939 and more dispensaries were opened. About 1,600 kgm. of quinine are distributed every year, health education is carried out intensively, nearly 350,000 pesos are set aside yearly for preventive work, and private donations add 50,000. In 1940, 30,250 houses were visited, in 8,210 of which mosquitoes were found, chiefly *Anopheles pseudopunctipennis* and also a few *A. arsimaculatus*, *A. argyritarsis*, *A. perizi* and *A. albitarsis*. Drainage, filling in, and other sanitary procedures were carried out on a large scale. More than 200,000 litres of petroleum and 70,000 kilos of Paris green were used.

Public Health in Chile

THE March issue of the *Boletín de la Oficina Sanitaria Panamericana* contains a survey by Dr. Pedro Aguirre Cerda, president of Chile, on the present state of public health in the Republic. Since the end of 1939 the country has been free from epidemic disease with the exception of one or two sporadic cases of typhus. Whereas, in 1938, 70 per cent of the conscripts serving in America contracted malaria, in 1940, there was not a single case. Special attention has been given to maternal and child welfare, and it is hoped that the present high infant mortality will be considerably reduced in two or three years. A scheme of medical attention is being planned to provide for mothers from the onset of pregnancy and for children from birth until they are able to work. The acute housing problem is being solved by providing hygienic and comfortable homes for workers at a low cost. Popular restaurants served approximately 2,000,000 meals to 1,000,000 persons in 1939, and 4,000,000 meals to 1,200,000 in 1940; 5,000,000 pesos have been allocated to aid deserted mothers and children as well as other handicapped persons.

Earthquake in Spain

An earthquake was felt in Granada in southern Spain early on July 12. According to human perception, the shock lasted for about ten seconds, although no damage or casualties have been reported. The epicentre was estimated to have been some eighteen miles from the city, and a slighter aftershock was felt a few minutes later. Since earthquakes show a marked tendency to recur in areas once affected, it is not surprising that earthquakes such as this one should occur. In southern Spain such shocks and smaller tremors are by no means infrequent, though probably one of the largest earthquakes to occur in Spain was that on November 1, 1755, near Lisbon, the written records of which were studied by the late Dr. C. Davison.

Earthquakes in South America

THE United States Coast and Geodetic Survey, in co-operation with Science Service and the Jesuit Seismological Association, has determined the epicentres of two recent South American earthquakes. From seismographic reports from twenty-two observatories, the epicentre of the earthquake of May 14 at 2h. 13·3m. U.T. provisionally turned out to be near lat. 1° S., long. 79° W. This is near the town of Riobamba, in Ecuador. From reports from five stations, the provisional epicentre of the earthquake of May 14 at 8h. 39.0m. U.T. turned out to be on the bed of the Pacific Ocean, off Tumaco in Colombia. Both epicentres are in well-known seismic regions.

Earthquakes in New Zealand

DURING April 1942, ten strong distant earthquakes were registered on the seismographs situated in various parts of New Zealand (New Zealand Seismological Report, Provisional Bulletin No. P-122). Additionally, there were twenty earthquakes which were felt in some part of the islands during the month. The strongest were on April 25 at 4h. 53·2m. U.T., which was felt with intensity 6 on the Rossi-Forel scale in the southern Hawke's Bay and Manawatu regions, and on April 26 at 00h. 26·3m. U.T., which was felt with intensity 5 (R.F.) in the neighbourhood of Upper Takaka. Other regions affected were Cook Strait and Christchurch, April 1, Hastings, April 2, Rotorua, April 8, Wairoa, April 18, Naseby, April 28, and Tokaanu, April 30. Minor activity was also recorded on several days at the observatories of Wellington, Christchurch, Auckland and Arapuni.

The strong New Zealand earthquake of June 24 which occurred at about 11.18 p.m. (local time) in the neighbourhood of Masterton (NATURE, July 4, p. 18) was strongly recorded with a full suite of pulses at Kew Observatory. According to the provisional interpretation of the seismogram at Kew, the vertical record received $ePKP_1$ at 11h. 36m. 32s. U.T. on June 24. On this record a maximum ground movement at Kew of 86 μ was attained at 13h. 04m. 15s. U.T. and the recording finished at about 17h. U.T.

Electrical Equipment of Buildings

THE Institution of Electrical Engineers has just issued recommended War Emergency Relaxations of the Regulations for the Electrical Equipment of Buildings (11th Edition), copies of which are available from the Institution free of charge, except where a number of copies is required. Regulation No. 304 relating to voltage-drop is amended, and the current ratings of certain cables are increased. The current-rating tables affected are Nos. 5 to 9 inclusive and 16. Two new tables, 5(A) for small single-core cables of earthed concentric wiring, and 10(A) for mineral insulated cables of 0·007 sq. in. cross-sectional area and above, are now added. Table 10(A) takes the place of Tables 10, 11 and 12 referred to in clause 302(B) for the cables in question. The purpose of the relaxations is to economize in materials.

Beit Memorial Fellowships for Medical Research

AT a recent meeting of the Trustees of the Beit Memorial Fellowships for Medical Research, Dr. A. N. Drury, Huddersfield lecturer in special pathology in the University of Cambridge, was appointed to the Advisory Board in succession to the late Prof. A. J. Clark. The Trustees noted with pleasure the election this year of three past fellows to the fellowship of the Royal Society, namely, E. Hindle (junior fellow, 1910–12, and senior in tropical medicine, 1927–33); F. M. Burnet (1926–27) and A. R. Todd (1935–36). Of the twenty-eight present fellows, there are now fourteen seconded for whole-time war-work.

The following elections have been made, with permission for each fellow to be seconded at any time for war duties: *4th Year Fellowship* (£500 a year). Mr. E. G. L. Bywaters, to continue his studies of crush injuries in relation to kidney function, at the British Postgraduate Medical School, London. *Junior Fellowships* (£400 a year). Dr. D. Herbert, to study the biochemistry of toxoids for active immunization against gas gangrene, at the Dunn Biochemical Laboratory, University of Cambridge. Dr. F. W. Landgrebe, to study the separation of posterior pituitary hormones, and their clinical uses, at the Medical School, University of Aberdeen.

The Night Sky in August

THE moon is new on August 12d. 02h. 28m. U.T. and full on August 26d. 03h. 46m. The following conjunctions will occur during the month: Aug. 2d. 04h., Venus in conjunction with Jupiter, Venus 0·3° S.; Aug. 6d. 09h., Saturn in conjunction with the moon, Saturn 3° N.; Aug. 9d. 05h., Jupiter in conjunction with the moon, Jupiter 4° N.; Aug. 9d. 21h., Venus in conjunction with the moon, Venus 4° N.; Aug. 13d. 15h., Mars in conjunction with the moon, Mars 0·7° N.; Aug. 19d. 13h., Mercury in conjunction with Mars, Mercury 0·01° S. Mercury is in conjunction with the sun on Aug. 2 and is an evening star at the end of the month. Venus is still a morning star. Mars is too near the sun for observation. Jupiter is a morning star in the constellation of Gemini. Saturn is a morning star north of Aldebaran. Occultations of stars brighter than magnitude 5 are as follows: Aug. 6d. 01h. 41·9m., 71 Tauri, R.; Aug. 6d. 01h. 58·8m., θ^2 Tauri, D.; Aug. 6d. 02h. 09·8m., θ^1 Tauri, D.; Aug. 6d. 02h. 44·0m., θ^1 Tauri, R.; Aug. 6d. 02h. 54·9m., θ^2 Tauri, R.; Aug. 30d. 00h. 49·4m., ν Piscium, R.

There will be a partial eclipse of the sun on Aug. 12, invisible at Greenwich. On Aug. 26 there will be a total eclipse of the moon, partly visible at Greenwich. The circumstances of the eclipse are as follows:

Moon enters penumbra	Aug. 26d. 01h.	01·7m.
,, ,, umbra	02	00·5
Total eclipse begins	03	00·9
Middle of eclipse	03	48·0
Total eclipse ends	04	35·0
Moon leaves umbra	05	35·3
,, ,, penumbra	06	34·0

The Perseid meteor shower will attain its maximum during Aug. 10–12.

Announcements

PROF. J. W. H. EYRE, emeritus professor of bacteriology, University of London, has been elected president of the Royal Institute of Public Health and Hygiene in succession to the late Sir Thomas Oliver. Prof. Eyre was senior vice-president and one of the founders in 1903 of the Institute of Hygiene, which amalgamated in 1937 with the Royal Institute of Public Health to form the present Institute.

AT a meeting of the Yorkshire Federation of Museums and Art Galleries, recently held at Huddersfield, Mr. T. Sheppard, formerly director of the Museums at Hull, was elected an honorary life member, "in recognition of his services to the International museum movement, and to the Yorkshire Federation in particular".

THE following appointments have been made in the Agricultural Department of the University of Leeds: Mr. J. B. Mackinson, honorary assistant to the Veterinary Investigation Officer; Mr. P. H. Brown, lecturer in horticulture; Miss E. M. Parker, assistant lecturer in agricultural bacteriology; Miss Margaret W. Crunan, instructor in rural domestic economy; Miss Elizabeth Darley, temporary instructor in poultry husbandry.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Number of Primes and Probability Considerations

SEVERAL months ago Lord Cherwell[1] directed attention to an apparent paradox which arises if one attempts to use probability considerations to determine the asymptotic density of prime numbers. The argument is this: The probability that a large number is not divisible by a prime p is $1 - \frac{1}{p}$. If we assume that such probabilities are independent for all pertinent trial divisors, we obtain as the density of primes near N^2 the value $\prod_{p<N}\left(1-\frac{1}{p}\right) \sim \frac{1}{e^\gamma \log N}$; the correct value, however, is $\frac{1}{2 \log N}$.

It is, of course, possible for mathematicians to dismiss such a question at once as unworthy of any consideration[2]. On the other hand, there are probably few physicists who would not feel at first sight that this is an eminently reasonable—perhaps even the only 'really' reasonable—approach to the problem, "How likely is a number near N^2 to be prime?". This feeling carries with it an obligation to try to account for the difficulty.

As Lord Cherwell remarks, the discrepancy must come from the fact that the probabilities are not independent. That they *may* not be independent is obvious. It can easily be shown that $\prod_{p<N}\left(1-\frac{1}{p}\right)$ is the *mean* density of numbers not divisible by any prime less than N, in the sequence of numbers 1, 2, 3, . . . $\prod_{p<N} p$; but numbers near N^2 are in a highly special position—very near the beginning—in this long sequence, so that there is no basis for identifying this particular *local* density with the mean density.

Now, the density near N^2 of numbers which are divisible by p but not divisible by any smaller prime is $1/p$ times the density near N^2/p of permissible quotients: that is, of numbers not divisible by any prime less than p. If $p > N^{2/3}$, such quotients must themselves be prime; for $N^{1/2} < p < N^{2/3}$, they may be either single primes or products of two primes, each $\geqslant p$; and so on.

Thus the density of primes near N^2 must be equal to: [density near N^2 of numbers not divisible by any prime less than $N^{2/3}$] minus $\left[\sum_{N^{1/2}<p<N} \frac{1}{p}\right.$ (density of primes near $\left.\frac{N^2}{p}\right)]$. If we take $\prod_{p<N^{1/3}}\left(1-\frac{1}{p}\right)$ as a rough value for the first term, and evaluate the second by using the formula $\frac{1}{\log u}$ for the density of primes near u when $N^{2/3} < u < N^{4/3}$, we get

$$\prod_{p<N^{1/3}}\left(1-\frac{1}{p}\right) - \int_{N^{1/3}}^{N} \frac{du}{u \log u \log \frac{N^2}{U}} = \frac{3e^{-\gamma} - \log 2}{2 \log N} = \frac{0{\cdot}9913}{2 \log N}$$

By replacing the assumption that the probabilities are independent by an asymptotically correct procedure in part of the range, we have reduced the error in the result to less than 1 per cent.

If the assumption that the probabilities are independent is used only as far as $N^{1/2}$, the density of numbers eliminated by trial divisors between $N^{1/2}$ and $N^{2/3}$ is given by a double integral. The result obtained for the density of primes near N^2 is $\frac{1}{2 \log N}$ times the factor

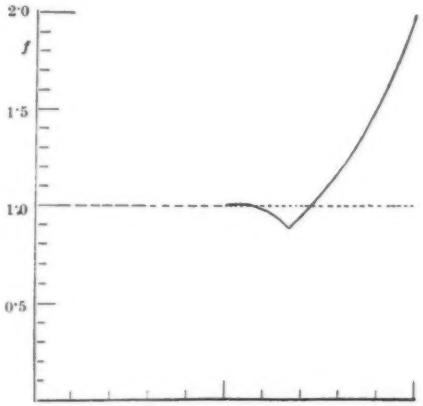
$$4e^{-\gamma} - \log 3 - \log 2 \,.\, \log \tfrac{3}{2} + \tfrac{1}{2} \sum_{k=1}^{\infty} \frac{1}{k^2 \cdot 4^k} = 1{\cdot}0000050.$$

It seems that the breakdown of the assumption that the probabilities are independent becomes considerable only for the larger trial divisors, and that we have a correct procedure to replace it there.

Another way of expressing the situation is as follows: The probability that a number n is divisible by a prime p is $1/p$, if concerning n we know only that it is large compared with p. If we know that n is *near* N^2 and *not divisible by any prime smaller than* p, then the probability that n is divisible by p is not $1/p$, but f/p. For $N \gg 1$, the factor f is a function of $\xi = \log p/\log N$; it vanishes for $\xi > 1$, and for $\xi < 1$ it can be calculated by using the sort of considerations described above. We find that

$$f(\xi) = \frac{2}{(2-\xi)\,[1 + \log(2-\xi) - \log \xi]}, \quad \tfrac{1}{2} < \xi < 1;$$

for $\frac{1}{3} < \xi < \frac{1}{2}$ a single numerical integration is required to determine f; and for smaller values of ξ the calculation is more complicated and has not been carried through.



The behaviour of the function f between $\xi = \frac{1}{2}$ and $\xi = 1$ is shown in the accompanying figure, and makes it seem extremely plausible that f is almost exactly unity for $\xi < \frac{1}{2}$—that is, that the trial divisors smaller than $N^{1/2}$ are practically independent in their action on the numbers near N^2. Since $f(1) = 2$, the last and largest of the trial divisors finds roughly twice as large a proportion of victims among the survivors of the previous trials as it would in a virgin population.

The considerations given here are, of course, of no value as a proof of the $1/\log u$ distribution of primes.

That theorem remains the property of students whose approach is more subtle than "probability considerations". The only use of the above remarks is to satisfy those who feel that the failure of the probability argument needs some elucidation, by showing how the factors do indeed tend to "avoid one another". I am grateful to Lord Cherwell for directing the attention of readers of NATURE to this question, and hope that he will find this answer satisfactory.

W. H. FURRY.

Department of Physics,
Harvard University,
Cambridge, Massachusetts.

[1] NATURE, **148**, 436 (1941).
[2] Hardy and Littlewood, *Acta Mathematica*, **44**, 36–37 (1923), especially footnote 4, p. 37.

I AM grateful to Prof. Furry for his sympathy with the outlook of a mere physicist and for the light he has thrown upon this matter. Prof. E. M. Wright, some months ago, sent me privately a proof on somewhat similar lines that the probabilities could not be independent for primes greater than $n^{0.76}$. Prof. Furry has carried the process a step further and shown the degree of divergence.

The mode of attack is not unlike one which I had pursued earlier without success. If ε is small compared with n, there seems no apparent reason why the density of composites containing prime factors less than n should not be the same in the neighbourhood of $n^2 + \varepsilon$ as it is in the neighbourhood of n^2. But in the neighbourhood of $n^2 + \varepsilon$, over and above the composites whose smallest prime factors are less than n, we must take account of the composites whose smallest prime factors lie between $\sqrt{n^2}$ and $\sqrt{n^2 + \varepsilon}$. Pursuing this line of thought, the following equation for the number of primes in the neighbourhood of z seems to emerge:

$$f'(z)_{z=n^2} = -\left(\frac{f(z)}{2z}\right)^2_{z=n}.$$

At first sight this seems promising since it is obviously satisfied by $f(z) = \dfrac{1}{\log z}$. But unfortunately it is also satisfied by the expression $f(z) = \dfrac{a}{z^{a/4}}$ where a may have any value, and I have not so far succeeded in finding any simple argument which excludes solutions of this type.

CHERWELL.

Christ Church,
Oxford.

Relationships of some Primitive Tetrapods

IN the final draft of an earlier letter[1], the occurrence of Diadectes in the late Stephanian was omitted by mistake. A misprint also needs correction, the index to reference 7 (par. 5, line 8) should follow "Moodie" (same line).

The opening sentence of par. 4 requires further comment. A somewhat similar structure is found in the Lower Carboniferous (Viséan) Otocratia, from the Burdie-house Limestone of Midlothian[2]. This skull has the otic notch nearly closed, and with one exception the skull-pattern (so far as it is known) is remarkably similar to that of Microbrachids and primitive Captorhinomorphs. The exception is the larger size of the postparietals, which exclude the parietals from contact with the tabulars. The structure of the homologous region in Osteolepids, Elpistostege, Ichthyostegids and most Stegocephalia is similar and undoubtedly represents the primitive condition. In Anthracosaurs, Microbrachids and early reptiles the postparietals are smaller, and the parietals and tabulars meet; in these forms the posterior part of the skull shows great shortening. It is therefore possible to regard the difference in structure between Microbrachids and Otocratia as due to increasing specialization of the former, for which Otocratia could thus provide a suitable morphological ancestry. In these forms the broad contact of the parietal and postorbital separates the supratemporal from the postfrontal, there is no separate intertemporal, and the orbits lie in front of the middle of the skull.

Otocratia is remarkably similar in skull-pattern to the Ichthyostegids and Elpistostege, except that its otic notch is obliterated by downward rotation of the tabular. The structure in Otocratia regarded by Watson as an internal nostril is too anteromesially placed, and appears to be the anterior palatal vacuity, bridged (as in some Osteolepids) by a strong median bar from the premaxillaries. The "advanced" features noted by Watson in this genus are found also in Ichthyostegids[3], and form indeed a very sharp contrast to early Embolomeres. I regard Otocratia as probably derived from Ichthyostegids. Its structure is suitable for the morphological ancestry of the Dinantian Adelospondyls described by Watson[2].

It is noteworthy that the earliest-known Embolomerous types (Loxommoids and Anthracosaurs) come from strata of Namurian age, while Otocratia, the Adelospondyls just mentioned and an undetermined "Lepospondyl"[2] are of late Dinantian (Viséan) age; the last-named is the earliest known 'Amphibian' skeleton except the Ichthyostegids. The vertebræ of these earliest forms have large centra and small or absent intercentra, as in Microbrachids and Captorhinomorphs. Currently accepted views on vertebral evolution seem to require adjustment.

I suggest tentatively that the Ichthyostegids and Otocratia, which are quite distinct from the commoner Labyrinthodont groups, are early members of a group of primitive Tetrapods which gave rise to the typical Microsauria and to the Diadectomorph and Captorhinomorph reptiles. I hope to discuss the implications of these observations and suggestions elsewhere.

T. S. WESTOLL.

Department of Geology and Mineralogy,
University of Aberdeen.

[1] Westoll, T. S., NATURE, **149**, 667 (1942).
[2] Watson, D. M. S., *Palaeont. Hungar.*, **1**, 221 (1926).
[3] Säve-Söderbergh, G., *Medd. Grönland*, **94**, Nr. 7 (1932).

Narcotic for Marine Invertebrates

THE following method is cheap and simple, and gives excellent results with such soft-bodied marine animals as have been tried (Polychætes, Doris, Priapulus, Nemertines, Ascidians). Make up 80 gm. of crystalline magnesium chloride in a litre of tap water. Immerse the animals in it. In one to four hours they will be relaxed and expanded. Add strong formalin to the magnesium solution; when they are dead, transfer to any desired fixative or preservative.

The solution is isotonic with sea-water, has apparently no irritating effects, and appears to be better and easier to use than menthol, cocaine, etc. In

Arenicola, at least, the tissues are undistorted and the material can be used for histological purposes.

The magnesium solution narcotizes but does not kill, at least for many hours. The narcosis can be rapidly reversed by transferring the animals back to sea-water.

ISABEL C. LEDINGHAM.
G. P. WELLS.

Department of Zoology,
University College,
London.
June 24.

Enamel Organ of the Rat's Incisor Tooth in Vitamin E Deficiency

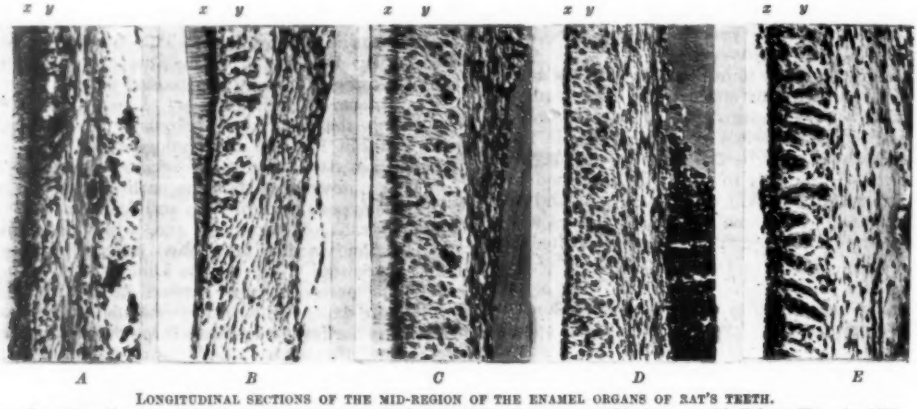
Davies and Moore[1] have pointed out that rats on a diet deficient in vitamins A and E suffered from a secondary vitamin A deficiency as evidenced by a disappearance of the vitamin from the liver; and also by a whitening of the incisor teeth, an effect which occurs in prolonged vitamin A deficiency[2] and was prevented by vitamin E dosage. Through the kindness of Dr. H. E. Brink, Department of Physiology, University of Stellenbosch, who has been working on vitamin E deficiency, I have been able to examine the incisor teeth of three female rats which had been on a vitamin E deficient diet[3] for 167 days from weaning. They had shown complete resorption of ambryos and the characteristic paralysis of the hind legs had just set in. The incisor teeth had the normal orange colour.

Longitudinal sections of the upper incisor teeth were cut and stained with hæmatoxylin and eosin. On microscopical examination, an abnormal degeneration was found in the enamel organ, which is illustrated in the accompanying photomicrographs (*A*,*B*).

It should be pointed out that in the rat's incisor, the enamel organ, and especially the ameloblasts, regress as they get older, having an average life of 50 days[4]. In young rats with rapidly growing incisors, the ameloblasts are still columnar when they reach the gingival margin, since they take only 25 days to get there; but in adult rats, the incisor grows more slowly and the ameloblasts regress in the anterior third of the tooth. If the tooth grows faster than usual, as can be caused by cutting off the exposed part, then the accelerated growth causes the ameloblasts to remain columnar up to the gingival margin[5], and conversely, if growth is slowed, the ameloblasts regress earlier. The rest of the enamel organ also regresses in a manner comparable to that of the ameloblasts. The epithelial papillæ, which are very prominent in the middle third of the tooth, gradually shrink, but can still be seen in the anterior third of the enamel organ.

The incisor teeth of the three vitamin E deficient rats showed a premature and abnormal degeneration of the enamel organ. This was found in the centre of the middle third of the tooth. One rat showed a disappearance of the epithelial papillæ and a shrinkage of the ameloblasts to an ill-arranged cubical layer (*A*) and the other two rats showed a sudden disappearance of all layers of the enamel organ, which was replaced by fibrous tissue (*B*). Comparable sections of the same part of the enamel organ from two normal female rats are given in *C*, *D*. These rats were 239 days old. These sections illustrate the degree of variability found under normal conditions in this area. In *C*, the ameloblasts are still distinctly columnar, while in the other (*D*) they have regressed to a considerable extent. In both, however, the epithelial papillæ are quite large and pronounced. The diet deficient in vitamin E used by Dr. Brink was not deficient in vitamin A, and thus no whitening of the teeth was seen, though it is true that these rats were younger than those reported by Davies and Moore. That no deficiency of vitamin A occurred is seen from a comparison of *A*,*B*, the latter being from the corresponding part of the enamel organ of a rat 150 days on a diet[6] deficient in vitamin A. This shows the characteristic atrophy of the ameloblasts and also the shrinkage of the epithelial papillæ which are found in this condition and which are quite unlike the changes found in *A*,*B*.

It would thus appear that rats on a diet adequate in vitamin A but deficient in vitamin E developed an atrophy of the enamel organ of an unusual type, unlike that caused by any other vitamin deficiency and possibly specific to vitamin E deficiency. It is of interest that vitamin E deficiency, apart from pro-



LONGITUDINAL SECTIONS OF THE MID-REGION OF THE ENAMEL ORGANS OF RAT'S TEETH.
In all sections the enamel has been lost during histological decalcification. *x*, ameloblasts, *y*, epithelial papillæ. (× 128)
A, *B*: Upper incisor teeth of two female rats 167 days on a diet deficient in vitamin E.
C, *D*: Two normal female rats 239 days old. *E*: Rat 150 days on a diet deficient in vitamin A.

ducing a dental change from secondary A deficiency as reported by Davies and Moore, may also itself cause a degeneration of quite different kind in the same area.

J. T. IRVING.

Department of Physiology,
University of Cape Town.

[1] Davies, A. W., and Moore, T., NATURE, **148**, 794 (1941).
[2] Wolbach, S. B., and Howe, P. R., *Amer. J. Path.*, **9**, 275 (1933); Smith, M. C., and Lantz, E. M., *J. Home Econ.*, **25**, 411 (1933); Irving, J. T., and Richards, M. B., NATURE, **144**, 908 (1939).
[3] Schoorl, P., *Arch. néer. Physiol.*, **19**, 403 (1934).
[4] Schour, I., Hoffman, M. M., and Smith, M. C., *Amer. J. Path.*, **17**, 529 (1941).
[5] Hoffman, M. M., Thesis, Univ. of Illinois. Quoted from ref. 4.
[6] Irving, J. T., and Richards, M. B., unpublished results.

Selective Excitation of Spectra by the High-Frequency Discharge

IN a series of preliminary investigations on the excitation of spectra by the high-frequency discharge, several interesting phenomena connected with intensity distribution have been observed, some of which have already been reported[1]. Further work indicates that these consist essentially in a redistribution of intensity among different band-systems of a diatomic molecule (that is, among different electronic energy levels) or among atomic energy states of different multiplicities. Thus the mercury spectrum observed shows that under certain well-defined and reproducible conditions, as for example pressure of gas, frequency of exciting oscillations, etc., only those lines are present which involve triplet initial states. Similarly, again under definite conditions, mainly those band systems of carbon monoxide are excited which involve only the singlet levels.

Keeping the pressure in the discharge tube constant, it is possible in the case of nitrogen, which has been studied so far, so to alter the relative intensities of the first positive and second positive band systems that either one or the other is more prominent at a given frequency of excitation. Thus it is found that with a gas pressure of about 7 mm. there is a critical value ($\sim$ 735 kc./sec.) for the frequency of oscillatory discharge, above which the second positive system and below which the first positive system gains in intensity. This is even more striking visually, the colour of the discharge undergoing a radical change when the frequency is altered.

The phenomena observed are different from those which involve a change of intensity distribution among various bands of a given electronic system. In the simplest case, such an effect will be a consequence of the interaction between the exciting particles and the vibrating nuclei, and has not been established so far in excitation by electrons[2]. In the presence of high-pressure argon[3], and in the afterglow spectrum[4], nitrogen exhibits such a change in distribution of intensity in its first positive band system, but obviously these involve different mechanisms.

The effects observed in the present series of investigations appear to be understandable from a consideration of the different excitation functions characteristic of the initial levels concerned. It has been possible to correlate all the facts with the form of the excitation function wherever this latter is known, thus making it possible to deduce the form of the excitation function in other cases where it may not have been known experimentally. The fact that this is at all possible, however, indicates that in the conditions under which the phenomena occur the following are true to a first approximation:

(1) The pressure in the discharge tube, the frequency of oscillatory discharge and the voltage across the electrodes determine, within a narrow range, the energy available for excitation.

(2) The main process of excitation involves only the emitters in the normal state; excitation through collisions of other kinds appears to be negligible.

Further work is in progress and details will be published elsewhere.

R. K. ASUNDI.
NAND LAL SINGH.

College of Science,
Benares Hindu University,
May 8.

[1] Asundi, Singh and Singh, *Proc. Ind. Sci. Cong.*, Part 2, 35 (1942); Asundi, Singh and Pant, *Proc. Ind. Sci. Cong.*, Part 3, 35 (1942).
[2] Langstroth, *Proc. Roy. Soc.*, A, **146**, 177 (1934); also **150**, 371 (1935). Hermann, *Ann. Phys.*, **25**, 2, 166 (1936).
[3] Johnson, *Phil. Mag.*, **48**, 1069 (1924).
[4] Fowler and Strutt, *Proc. Roy. Soc.*, A, **85**, 377 (1911).

The Problem of the Autonomy of Life

IN his letter published in NATURE of May 16, Prof. Donnan abandons his previous assertion that a potency for producing order resides in the temperature difference between two surfaces. He substitutes the obvious and indisputable statement that an energy disequilibrium is one of the necessary conditions for the production of the specific structure of a living organism. It is, of course, one of the necessary conditions for the production of anything, and so this does not get us any further. The cause of the discrimination of which there is evidence has still to be sought.

I am directing attention to this confusion between the *cause* of a phenomena, and the *conditions* which must pertain, so that the cause may become effective, because this is a very common confusion. It is at the bottom of many other attempts to explain the organic world. Among these is the attempt in Prof. Donnan's letter to do so by invoking photosynthesis. The problem, be it noted, is not merely why there may be in some cases, as Prof. Donnan puts it, "a decrease in entropy". The problem is far greater. It is to discover what in all living substance causes each particle to reach a specified position. *Why does the random incidence of photons lead to anything but a random arrangement of atoms?* The presence of enzymes and chlorophyll in living substance is (like the availability of energy) but one of the many conditions which must be met, so that the discriminating agent, whatever it be, may operate. To attribute discriminating powers to chemical substances would be medieval mysticism, so photosynthesis does not solve the problem. It is itself a part of the problem which we must seek to solve. The very presence of chlorophyll just in those places where it makes photosynthesis possible is another part of the problem.

If, as I have attempted to show, the source of the discrimination is not covered by even the widest definition of the word 'material', we certainly need, as Admiral Beadnell says, a new definition of 'non-material'. This definition must be neither so naive as to include things like electromagnetic radiation,

nor so anthropomorphic as to identify non-material with mind. I am hoping that Admiral Beadnell may be among those who can accept my understanding of the term, though it would take too much space to explain it here.

University College, London.

REGINALD O. KAPP.

IN my letter of May 16, to which Prof. Kapp refers, I tried to explain that the disequilibrium in question, involving as it does an increase of entropy, was a necessary (though, as I pointed out, not a sufficient) *condition* for the occurrence of the photochemical process, since the latter involves an increase of order and a decrease of entropy. I was careful to point out that the work of the biochemists and plant physiologists was necessary in order to complete the associated complex of conditions and processes which, together with the fundamental condition, constitutes a satisfactory causal analysis of the phenomenon. It will be obvious, I think, to those who have followed the discussion, that what Prof. Kapp now says constitutes a complete travesty of my remarks and demonstrates in the clearest manner that he has failed to understand their meaning.

I am glad, however, that Prof. Kapp has written this second letter, because readers of NATURE can now see for themselves Prof. Kapp's method of conducting *his* type of "causal analysis". Let me give one or two examples. The molecules of glucose are found to build up the starch granules in the chloroplasts of a plant cell. Why is this? Because they follow the course *specified* for them. A chemical substance *A*, when presented in an organism with a mixture of substances *B*, *C*, *D*, etc., is found to combine with *B*, but not with *C*, *D*, etc. Reason for this? Very simple, an unknown *X discriminates*. And so on, *ad infinitum*. This sort of thing is not even "medieval mysticism"; the medieval philosophers and scientists, though suffering in general from a great paucity of facts, were after all good rationalists. Sound and sufficient experiments and sound and sufficient reasoning make science. One cannot buy (or sell) it with the currency of mere words; though you may run a dumb film on captions.

The Athenæum, London.

F. G. DONNAN.

General and Social Biology

THE article by Mrs. S. Neville Rolfe in NATURE of January 24, p. 90, calls for comment and support. Does it occur to the average man that, except at some schools, everything taught is factual, with definite conclusions? For example, history, geography, grammar, mathematics, physics and chemistry all produce definite results. But when we enter the world in which we live, we are emerging into a world of living and thinking beings. The facts can be ascertained, though often with much difficulty, but the conclusions are too often matters of probability.

It is true that contact with the world teaches some men the peculiarities of social life and human nature. But I cannot understand a nation without any universal training in social biology taking the sound road easily. Their minds have not been trained as they should be.

In administration the defect is obvious, and the difficulties in the way of problems of health are known to many people who have seen them in the Colonial empire. One item—and it is only one item—illustrates. During the War of 1914–18—and there I can speak from personal knowledge of the difficulties—in the British and Dominion troops there were 400,000 reported cases of venereal disease, and in the American Army 340,000, that is, 740,000 in all, with an average absence from duty of five–six weeks and causing a heavy burden on the services. Could this have happened if the military direction had grasped the situation before it developed? Much the same thing may be said of malaria, which took a heavy toll, although Field Marshal Allenby realized the danger and acted accordingly.

How many people realize that there are 650 million people suffering from malaria—about 1 in 3 of the population of the world. But the very good medical education in the universities is directed chiefly towards the treatment of disease. The prevention of disease and the maintenance of health, apart from disease, do not receive much attention. The social problems of housing, play space, town planning, etc., scarcely enter the medical curriculum.

Prevention means not only advice but also the active concurrence of everyone. But the general mass of the population, untrained in biology, will continue to make serious mistakes. All universities naturally divide their work into compartments, but the great problems of life very often do not fit into any compartment, and have to be attacked by other methods; hence the need for some form of sociological training.

JAMES W. BARRETT.

103–105 Collins Street, Melbourne, C.1.

Higher Algebra

MY attention has been directed to an unfortunate error in my review of "The Tutorial Algebra" in NATURE of July 11, p. 39. In fairness to the author especially, I should like to correct this. My query, "Is the condition . . . biquadratic?", should have referred to the converse, namely, Does the condition $ac-b^2>0$ hold for every biquadratic having at least two complex roots? My chief concern was to prevent the inference that the roots are all real when $ac-b^2$ is not positive; hence the example. I think the whole point would become quite clear if a brief note were added at the end of the proof of example (2) on p. 510 indicating (i) what happens when H is not positive or equal to zero, and (ii) whether the converse to the theorem proved is true, H being $ac-b^2$.

F. G. W. BROWN.

Pyrethrum Sprays

IN my article published in NATURE of June 27 (p. 720) on "Biological Assay of Insecticidal Sprays", it was stated that a solution of pyrocatechol in ether was recommended as a stabilizer for the standard pyrethrum spray. It must be pointed out that this statement should apply only to a pyrethrum solution used as a standard for comparison in laboratory tests.

A solution of this type, in which ether is employed, would not be suitable for incorporation in a pyrethrum spray intended for commercial use, and the statement concerning its addition does not form part of the standard specification for this type of spray.

E. A. PARKIN.

Pest Infestation Laboratory, Slough, Bucks.

MINERAL AND VITAMIN REQUIREMENTS AND THE WAR-TIME DIETARY

AT a discussion in the Section of Medicine of the Royal Society of Medicine on May 26 on mineral and vitamin requirements and the war-time dietary, some interesting and important points were brought out, though the subject is very wide and could therefore be covered only in part because in the last limit it embraces both the qualitative as well as the quantitative requirements.

Mineral Requirements

Dr. R. A. McCance confined his attention mainly to calcium and iron, saying that sodium, potassium, magnesium, zinc and phosphorus and the 'trace elements' such as copper and manganese can be left to themselves. He opened by stating that to maintain ourselves in perfect health we have to *absorb* just as much calcium, phosphorus and other mineral elements as before the War; even then there was a belief that calcium and iron were deficient. In the modified and planned war diets, there is now plenty of milk for children but little for adults. The calcium and iron intake is maintained by the 85 per cent extraction loaf which has 2–3 times as much iron as in white bread. The problem is whether these two minerals are as well absorbed as in peace-time. In an investigation by Drs. McCance and Widdowson upon human subjects (taking more than fourteen months) the calcium proved to be less well absorbed when brown 92 per cent extraction flour was substituted for white flour in the diet. The same has been found more recently with iron, though the results need some repetition. The nature of the factor responsible for depression of absorption has emerged as the result of much research. E. Mellanby earlier stressed the presence of a rachitogenic factor in some cereals, especially oatmeal. Much later (1934) Bruce and Callow suggested that this might be inositol hexaphosphoric acid, a compound present in the outer parts of the cereal grains. In 1939 Harrison and Mellanby showed that addition of sodium phytate to puppies' diet led to rickets. It was left to McCance and colleagues to prove that the addition of sodium phytate to white bread depressed absorption of calcium and magnesium more than the brown bread diets, some subjects even excreting more calcium in the faeces than they took in the food (due to fixation of calcium in some of the intestinal secretion). Removal of phytin in bread is possible on the experimental scale though impracticable commercially, and does not completely reduce the error in absorption. Nor does vitamin D in physiological doses improve the absorption of calcium in adults. The cheapest and simplest way to counteract the action of the phytic acid is to add calcium as calcium carbonate to precipitate the phytic acid and so leave the remaining 'calcium' available for absorption. In the 85 per cent loaf this is about half the amount of phytic acid present in the '92 per cent'. Dr. McCance considers that the physiological arguments for addition of calcium (as calcium carbonate) to the 85 per cent loaf are very strong and that we should have the courage of our convictions and support the addition to maintain adequate calcium absorption. A similar argument holds for iron.

Prof. R. A. Peters in a short communication produced X-ray pictures by Dr. Kemp, of Oxford, to demonstrate that in a man of 52–53 years the addition of calcium carbonate to the maximum amount recommended by Dr. McCance and adopted by the Medical Research Council (namely, 14 oz. per 280 lb. flour) to 85 per cent extraction bread has produced no signs either of calculus or calcification of the femoral arteries. His family has lived on this bread (+ chalk) for thirteen months with no noticeable ill-effects, as indeed would be expected, when it is realized that the addition is only 1/20 oz. calcium carbonate in 1·3 lb. bread.

Dr. Murray Scott discussed minerals from a practitioner's point of view; as chairman of a local borough committee on bread, he has been trying to get evidence of deficiencies attributable to faulty diet, etc. In his part of the country medical and obstetrical opinion asserted there is increasing anæmia; examination of miners' wives showed reduction in hæmoglobin, and indicated that the miner frequently eats all the meat and cheese in the family ration. For several years second-year medical students at Leeds have estimated their own hæmoglobin; for the six years before the War the numerically largest group has always been in the 100–105 per cent hæmoglobin division. Last year, it was the 90–95 per cent division. A careful survey of prices in August 1941 showed that for an active man a complete optimum diet could not be purchased for less than 14*s.* a week, and for sedentary workers 11*s.* per week. Since the rationing of meat, bacon, eggs and cheese reduces the intake of iron to 1–2 oz. a day from this source, there is a theoretical expectation of increasing anæmia among the poorer half of the nation. The change to 85 per cent extraction meal will increase the iron of the diets for most people by about 2·5 mgm. a day, without disturbing the supply of calcium and phosphorus which comes from the milk, though the use of some of the wheatings in the new flour will deprive pigs and poultry of part of their present supply. In considering possible disadvantages of 85 per cent extraction flour, Dr. Scott was struck with the apparent discrepancy between the conclusions of Widdowson and McCance's experiments on iron and his general ideas, and wished to have evidence of lack of energy or fall in hæmoglobin. He instanced the case of two adults in his own household, who have eaten entirely wholemeal bread, and yet have hæmoglobins of more than 100 per cent. How does their iron escape the clutches of the phytic acid? In a speculative vein, he asked whether it is possible that prolonged eating of white bread led us to lose a capacity to deal with phytic acid (by phytases or otherwise) which was possessed by our ancestors. In conclusion, he expressed the view that diets contain less total iron than pre-war and that it is important to solve the question of how to increase the available iron in the nation's diet, preferably through bread.

In the parts of the subsequent discussion which bore upon minerals, Dr. H. M. Sinclair pressed for supplements of iron in the national dietary. Dr. A. P. Meiklejohn, in dealing with the question whether the addition of iron to bread was justified upon the evidence so far produced, stated that in a recent survey in Lancashire a random sample of young married women had (low) hæmoglobin limits of about 75 per cent (Haldane scale). Dr. Geoffrey Evans was impressed by the number of persons who had hæmoglobin values below 85 per cent and the obvious improvement by giving iron.

Prof. J. R. Marrack was a sceptic upon the possible 'de-mineralizing' effect of brown bread, as he has always eaten it and been able to play rugby football until he was forty-four. Dr. R. J. Atkins referred to the importance of trace elements and to the presence in soil of elements like manganese which interferes seriously with the absorption of iron. Mr. A. L. Bacharach said that in order to increase the general intake of iron by 5 mgm. per person a day, only eighty tons of iron salts would be needed, and that it was quite easy to carry this out with bread.

Dr. McCance, replying to several points, pointed out that the calcium requirement of individuals shows large variation; some would store calcium on a diet which would lead to loss of calcium in others. This probably explained Prof. Marrack's point. It makes the postulate of an absolute average requirement difficult, and indicates the need for playing for safety.

Summarizing this side of the discussion, there seems to be a general belief in the need for calcium and iron supplements in the diet, in some form, of which bread appears a reasonable medium.

Vitamin Requirements

The requirements of vitamins in the dietary were less thoroughly discussed, the main attention being given to vitamin C. Dr. L. J. Harris urged the existence of subclinical deficiencies. He directed attention to animal experiments in which it could be demonstrated that there is a grading of response to vitamin B_1 between the optimal dosage-level and one giving definite signs of deficiency. It is unlikely that this does not apply to man. He considers that his investigations have shown that levels of nutrition of some vitamins could be judged quantitatively by statistically controlled 'saturation tests' upon groups of people; this must not be taken to mean that he thinks that perfect nutrition is only co-existent with saturation. In the urinary saturation tests for vitamin C, the level of nutrition is judged by the speed with which the urinary excretion with test doses reaches on average a plateau; this takes only one or two days in subjects receiving proper amounts of the vitamin in their diet. Absence of scurvy does not mean necessarily having enough vitamin C. There occurs in man those symptoms of deficiency seen in guinea pigs, namely, diminished growth-rate, failure in the production of new tissues and increased liability to infection. He cited work from German official records in support of the view that extra vitamin C improves the annual gains in weights and height of children and diminishes the incidence of infections (1,600,000 children were given 50 mgm. vitamin C daily in addition to the ordinary war-time diet). In Britain, Glazebrook and Thomson have found less duration of tonsillitis and less disease in naval trainees dosed with vitamin C. Further, Crandon and associates in America and Hunt in Great Britain believe in the value of vitamin C in the healing of wounds; but it is true that the effect upon Crandon himself did not appear until a late stage in his vitamin C deficient diet. On the other side he quoted the view of Zilva (an authority on vitamin C) that even allowing for destruction in cooking, the war-time diet contains enough vitamin C, and also the observations of Fox and colleagues; the latter found that out of 950 miners getting 12–25 mgm. of ascorbic acid twelve developed scurvy, whereas only one out of a similar number getting an extra 40 mgm. developed scurvy.

This point was taken up by Dr. Sinclair, who thought that it created much difficulty in regard to subclinical deficiency, because there was no difference in incidence of infection in Fox's experiments. On the other hand, Dr. Meiklejohn said that long before Dr. Crandon showed signs of vitamin C deficiency he looked a sick man and suffered from vague symptoms of lassitude.

Dr. Harris also referred to the results of some of his saturation tests. Children at a good residential institution showed consistently higher levels of excretion of vitamin C than those from poorer homes; but during the War the level of both groups has fallen; this was more marked in the winter months and justified the decision to set aside supplies of vitamin C for young children.

In relation to this, Prof. Marrack said that in March and April he estimated ascorbic acid in a number of meals in school canteens and British Restaurants, where he found no evidence of excessive destruction in the preparation and cooking. The total ascorbic acid calculated as supplied for one third meals was less than 10 mgm. and for one third was more than 20 mgm. There was evidence that in saturation tests the number of boys saturating on the first day of giving the test dose increased with the average ascorbic acid content of the diet at the school. The highest saturation was in the school which grew abundant early green vegetables, and the choice of vegetables grown is important. It is unwise to trust to raw vegetables.

Dr. Atkins raised some critical points over the saturation tests. He found that in fifty men from the same kitchen differences of saturation occurred according to whether they had their vitamin C tablets before or after breakfast. Further, 40–100 left saturated ten months ago, showed no quicker saturation in a subsequent period of dosing than those previously unsaturated.

In conclusion of his remarks, Dr. Harris said 9 per cent of children in an institution, 15 per cent among urban children, and 18 per cent among village children could be improved by a vitamin A dosing, using a dark adaptation test (Yudkin). Six per cent of school children examined at Cambridge showed riboflavin deficiency (vascularization of the cornea by slit lamp examination). Dr. Geoffrey Evans from his own experience believes in the existence of deficiencies to-day, and stated that cases of acne rosacea with conjunctivitis and mild degrees of keratitis could be improved by giving riboflavin, and cases of fatigue and depression with vitamin B_1. Dr. Magee, striking a critical note, considered that not enough attention had been paid in the discussion to the quantitative requirements and pointed out the great differences between the standard for proteins and minerals which had been arrived at as the result of clear-cut experiments, and the vitamins. For these he regarded the evidence as still more approaching guess-work or speculation.

It is the opinion of the reviewer that the problem of actual quantities of vitamins required could well be discussed again, when more information is available. In regard to this vexed question of 'subclinical deficiency', it must be conceded that evidence is accumulating that levels of saturation of some vitamins may fall to a point which is dangerous in the sense that individuals may be too close to the point of actual deficiency. Such depletion periods will not matter so long as they are only biochemical, provided that they are reversed in time, because

there may be still enough vitamin about to run essential biochemical processes. If, however, there is also the ill-health suggested, it is important; but its very vagueness must increase the need for caution and for prolonged experiments (taking into account all psychological factors) before coming to a final judgment. It is difficult to see how the state of the individual (as distinct from statistical averages over a group) can be assessed without combining blood estimations with clinical examinations, as Dr. Sinclair and his colleagues are trying to do. So much for the purely scientific attitude. Meanwhile we are faced with practice in the War. We know from McCance and Widdowson that there is a wide difference in calcium requirements of individuals; we have the League of Nations standards for the earlier vitamin factors, but none for those more recently discovered; we know that even animals are individual in their needs of a vitamin like aneurin. Let us hope that ultimately we may be able to recognize on a scientific basis cases where intake of a special factor must be increased for an individual. For the moment we are left with the dilemma that diets must provide sufficient margin of accessory factors to ensure no physical inefficiency, and we must see that time and valuable foodstuffs (synthetic and natural) are not wasted; fortunately, the latter does not apply to chalk and iron.

R. A. PETERS.

AMINO ACID ANALYSIS AND THE STRUCTURE OF PROTEINS*

By PROF. A. C. CHIBNALL, F.R.S.

IN recent years X-ray crystallographers have made remarkable advances in the interpretation of protein structure, and it is becoming more and more evident that a stage has been reached when their views need to be reconciled with data obtained from accurate amino-acid analysis of the proteins concerned. In 1934 Astbury suggested that in gelatin the residues of glycine and hydroxyproline must repeat at regular intervals along the peptide chain, an idea developed in the following year by Bergmann and Niemann into a general hypothesis that (briefly) the 'frequency' of recurrence of any particular residue must be factorizable entirely by 2 and/or 3, as must also the total number of residues in the molecule. Evidence in its favour was adduced from analytical data for several proteins, including egg-albumin. The hypothesis has been criticized on various grounds, chief among them being that existing methods of analysis are in most cases not sufficiently quantitative to warrant the results being interpreted with the precision needed. What are believed to be quantitative estimations for the bases and dicarboxylic acids in edestin, egg-albumin and β-lactoglobulin have now been obtained.

Edestin.—The analytical data and calculated mean residue weight (115·7) show that the smallest possible unit contains 432 ($2^4 \times 3^3$) residues, and that the number of residues of arginine, histidine, lysine, tyrosine, tryptophan, methionine and cystine are 48, 8, 8, 12, 4, 8 and 3 respectively. On the assumption that the amide-nitrogen can be distributed in such a way that the number of residues of asparagine, aspartic acid, glutamine and glutamic acid are also factors of 432, it can be shown that these must be 27, 18, 36 and 36 respectively. The data lend support to the Bergmann and Niemann hypothesis, but at present there is no evidence that edestin is homogeneous.

β-Lactoglobulin is homogeneous. The analytical data suggest a molecular weight of 42,000, in agreement with physical measurement, but the total number of residues is not factorizable by 2 and/or 3. The Bergmann-Niemann hypothesis is thus not valid. On the assumption that the molecule is one peptide chain, the number of carboxyl groups computed from titration curves is in agreement with the chemical data, but the number of free amino groups is eight more than can be attributed to lysine. The molecule is a system of nine peptide chains, not all of like composition, coupled by linkages involving carboxyl and not amino groups. Imide and thiol-ester linkages are suggested; the presence of the latter would explain many puzzling features of denaturation.

Egg-albumin is not homogeneous and tells a somewhat similar story. Chemical data suggest a molecular weight of 43,000, in conformity with physical measurements; the Bergmann-Niemann hypothesis does not hold. From titration and other data it is suggested that the molecule is a system of at least four peptide chains having free terminal amino groups, recalling Astbury's deduction that the denatured protein is a pile of four laminæ.

Insulin.—If the excess of free amino groups is a measure of the number of peptide chains, as in lactoglobulin, the molecule of insulin must be a system of eighteen such chains, a striking confirmation of Bernal's prediction from the peaks in the Patterson projection.

Reverting to *edestin*, it has been found that the determination of free amino groups is complicated by edestan formation. It is probable that the submolecule of 50,000 is one peptide chain, though the possibility that it is a system of three peptide chains of unlike composition cannot be dismissed, in which case the allocation of the amide-nitrogen given above would not be justified. Nevertheless, the stoichiometric relationships exhibited by the other residues are sufficiently impressive to warrant the assumption that the constituent peptide chains would be built to essentially the same pattern based on $2^n \times 3^m$, though they might not contain the same number of residues. All other proteins may be similarly constituted. Such views emphasize the need for more work on the isolation and characterization of the partial decomposition products of protein, for much of the evidence hitherto brought forward to support the Bergmann-Niemann hypothesis has been based on inadequate experimental data and has demonstrated nothing more than the hypnotic power of numerology.

* Substance of the Bakerian Lecture delivered before the Royal Society on July 16.

TIMBER-SEASONING KILNS

TWO leaflets have recently been issued by the Forest Research Institute, Dehra Dun, India, on the subject of timber seasoning kilns by M. A. Rehman, Utilization Branch (For. Res. Inst. Public. Vasant Press, Dehra Dun, 1941–42). Leaflet No. 11, "Types of Timber Seasoning Kilns suitable for drying Indian Woods" (1942), describes briefly the various types of seasoning kilns which have been designed or tested by the Forest Institute. It was due to the position in which we found ourselves during the last War in the matter of timber supplies, especially

perhaps in the demand for, and absence of, seasoned timber for the increasing aeroplane construction, that led to the first marked improvements in artificial kiln seasoning. Experiments and research in this direction were taken up at the Institute in the early years after the War, and this small leaflet gives briefly some of the results which have been reached —results which are at least as important economically as in temperate zones. The general principles of the steam-heated internal-fan kiln and four types of furnace kilns are discussed, the direct-heated forced-circulation furnace kiln, the indirect-heated internal-fan furnace kiln, the new F.R.I. furnace kiln and the hot air kiln. The results of tests show that a steam-heated internal-fan kiln is suitable for the seasoning of almost all kinds of woods. Of the furnace kilns, the first mentioned above is suitable for drying furniture woods, the second for drying packing-case timbers only, the third for the slow seasoning of furniture woods and the fourth for completing the drying of partially air-seasoned half-wroughts for the manufacture of certain types of articles. The third of these furnace kilns is cheaply manufactured, was designed at the Research Institute and is termed the indirect-heated thermal-circulation furnace kiln.

The fourth furnace kiln, the hot air kiln, briefly alluded to here, is discussed in detail in Leaflet No. 5, issued by the Research Institute in 1941. It is common knowledge that air-seasoning of timber is slow but yields eminently satisfactory results, well known to previous generations. In these hurrying days of greater demand, assisted by two major wars, the periods required to produce air-seasoned material of the various species of timbers are too long. As an example, 1-inch planks of hardwoods suitable for furniture manufacture take at least three to four months to become properly air-seasoned, and larger-sized timber correspondingly longer. The kiln considerably reduces the period. For example, it is estimated that $2\frac{1}{2}$ in. $\times$ $2\frac{1}{2}$ in.-blanks of refractory hardwoods cut from planks which have been air-seasoned for about two months can be completely seasoned in about fifteen days in a hot air kiln of this type. This kiln is a masonry chamber provided with a number of ducts in the floor through which hot gases from a wood-burning furnace are passed. The chamber is fitted with racks for holding the half-wroughts of wood to be seasoned. These consist of shuttles, bobbins, picker arms, helves and tool handles.

FORTHCOMING EVENTS

(Meeting marked with an asterisk is open to the public)

Friday and Saturday, July 24-25

BRITISH ASSOCIATION (DIVISION FOR THE SOCIAL AND INTERNATIONAL RELATIONS OF SCIENCE) (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 10 a.m.—Conference on "Mineral Resources and the Atlantic Charter", to be opened by Sir Richard Gregory, Bart., F.R.S.*

Friday Morning Session

Chairman: Sir Thomas Holland, K.C.S.I., F.R.S.; Speakers: Prof. H. H. Read, F.R.S., Prof. P. G. H. Boswell, F.R.S., and Prof. C. B. Fawcett.

Friday Afternoon Session

Chairman: Sir William Larke; Speakers: Prof. W. R. Jones, Sir Lewis Fermor, F.R.S., Lt.-Col. the Hon. Colin A. Campbell.

Saturday Morning Session

Chairman: Dr. C. H. Desch, F.R.S.; Speakers: Dr. E. F. Armstrong, F.R.S., Dr. W. H. Hatfield, F.R.S., Dr. David Williams, and Sir Harold Hartley, F.R.S.

Saturday Afternoon Session

Chairman: Sir Stafford Cripps, P.C.; Speakers: Prof. J. G. Smith, Dr. W. A. Lewis, Dr. E. P. Penrose, Mr. A. Notman, Dr. O. W. Roskill, and Dr. L. Dudley Stamp.

Tickets from the Secretary, British Association, Burlington House, Piccadilly, London, W.1.

Saturday and Sunday, August 1-2

ASSOCIATION OF SCIENTIFIC WORKERS (IN COLLABORATION WITH THE FEDERATION OF AYRSHIRE SCIENTIFIC FILM SOCIETIES) (at Ayr).—Conference on "The Scientific Film and Scientific Film Societies".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

VETERINARY INVESTIGATION OFFICER—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow (July 30).

LECTURER in MATHEMATICS in the Technical College, Cardiff—The Director of Education, City Hall, Cardiff (July 31).

GRADUATE IN ENGINEERING TO TEACH TECHNICAL SUBJECTS AND ALSO TO ACT AS ORGANIZER OF THE TECHNICAL CLASSES in the Basingstoke Queen Mary's School and Technical Evening School—The County Education Officer, The Castle, Winchester (endorsed 'Basingstoke') (July 31).

TWO DEMONSTRATORS (MALE OR FEMALE) IN ANATOMY—The Registrar, The University, Sheffield (July 31).

LECTURER IN THE DEPARTMENT OF CHEMISTRY—The Registrar, University College, Southampton (August 4).

LECTURER IN MECHANICAL ENGINEERING in the Cannock Chase Mining College—The Director of Education, County Education Offices, Stafford (August 7).

HEAD OF THE ENGINEERING DEPARTMENT at the County Technical College, Wednesbury, and COUNTY LECTURER IN ENGINEERING for South Staffordshire—The Director of Education, County Education Offices, Stafford (August 7).

LECTURER FOR EVENING CLASSES IN CHEMISTRY—The Principal, Technical College, Kingston-upon-Thames, Surrey.

GRADUATE IN ENGINEERING, and a GRADUATE FOR GENERAL SCIENCE AND MATHEMATICS, at the Eastbourne Technical School—The Education Officer, Education Offices, Eastbourne.

CHEMIST OR CHEMICAL ENGINEER WITH EXPERIENCE OF RUNNING AMMONIA SODA PLANTS and with knowledge of the heavy chemical industry, for India—The Secretary, Overseas Manpower Committee (Reference 338), Ministry of Labour and National Service, Hanway House, Red Lion Square, London, W.C.1.

TWO DEMONSTRATORS IN PHYSIOLOGY—The Professor of Physiology, The University, Liverpool.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Polish Science and Learning. Edited for the Association of Polish University Professors and Lecturers in Great Britain. No. 1, June. Pp. 68. (London: Oxford University Press.) 2*s.* 6*d.* [87

Geological Survey of Great Britain: England and Wales. Wartime Pamphlet No. 25: The Geology of the Warwickshire Coalfield in New Series One-inch Sheets 154–5, 168–9, 184. By Dr. G. H. Mitchell; with Animal Palæontology, by Dr. C. J. Stubblefield, and Plant Palæontology, by Dr. R. Crookall. Pp. 40. (London: Geological Survey and Museum.) 1*s.* 10*d.* [97

Annual Report of Gresham's School Natural History Society, 1942. Pp. ii+18. (Holt: Gresham's School.) [137

Annual Report of the Council of the Yorkshire Philosophical Society for the Year 1941. Pp. 24. (York: Yorkshire Museum.) [137

Ollsgoil na h-Éireann: the National University of Ireland. Calendar for the Year 1941. Pp. x+268+418+52. (Dublin: National University of Ireland.) [137

Other Countries

Flora of Fukien and Floristic Notes on Southeastern China. By Prof. Franklin P. Metcalf. Fascicle 1. Pp. xvii+82. (Canton: Lingnan University.) [87

Forest Bulletin No. 100 (Utilisation, New Series): Wrapping and Packing Papers from Ulla Grass (*Themeda arundinacea*, Ridley, Syn. *Anthistiria gigantea* Cav.). By M. P. Bhargava and Chattar Singh. Pp. iii+13. (Delhi: Manager of Publications.) 6 annas; 7*d.* [87

Sudan Government: Wellcome Chemical Laboratories, Sudan Medical Service. Report of the Government Analyst for the Year 1941. Pp. 19. (Khartoum: Wellcome Chemical Laboratories.) [97

Proceedings of the United States National Museum. Vol. 92, No. 3136: A New Species of Phyllopod Crustacean from the Southwestern Short-Grass Prairies. By J. G. Mackin. Pp. 33–39. (Washington, D.C.: Government Printing Office.) [107

Smithsonian Miscellaneous Collections. Vol. 101, No. 14: Two New Fossil Birds from the Oligocene of South Dakota. By Alexander Wetmore. (Publication 3680.) Pp. ii+6. (Washington, D.C.: Smithsonian Institution.) [107

Smithsonian Miscellaneous Collections. Vol. 101, No. 15: Fifth Contribution to Nomenclature of Cambrian Fossils. By Charles E. Resser. (Publication 3682.) Pp. ii+58. (Washington, D.C.: Smithsonian Institution.) [137

Catalogues

Wild-Barfield Heat-Treatment Journal. Vol. 4, No. 32–33. Pp. 71–78. (Watford: Wild-Barfield Electric Furnaces, Ltd.)

A Catalogue of Books on Entomology and General Natural History) (No. 600.) Pp. 28. A List of Selected New and Recent Publications (New Book List No. 15.) Pp. 6. (London: Bernard Quaritch, Ltd

General Catalogue. (Catalogue No. 661.) Pp. 86. (London: Francis Edwards, Ltd.)